Dark Nuclear Physics and Condensed Matter

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Abstract

The unavoidable presence of classical long ranged weak (and also color) gauge fields in TGD Universe has been a continual source of worries for more than two decades. The basic question has been whether Z^0 charges of elementary particles are screened in electro-weak length scale or not. For a long time the hypothesis was that the charges are feeded to larger space-time sheets in this length scale rather than screened by vacuum charges so that an effective screening results in electro-weak length scale.

A more promising approach inspired by the TGD based view about dark matter assumes that weak charges are indeed screened for ordinary matter in electro-weak length scale but that dark electro-weak bosons correspond to much longer symmetry breaking length scale.

1. What darkness means?

It is not at all obvious what darkness means and one can consider two variants.

a) The weak form of darkness is that only some field bodies of the particle consisting of flux quanta mediating bound state interactions between particles become dark. One can assign to each interaction a field body (em, Z^0, W, gluonic, gravitational) and p-adic prime and the value of Planck constant characterize the size of the particular field body. One might even think that particle mass can be assigned with its em field body and that Compton length of particle corresponds to the size scale of em field body. Complex combinations of dark field bodies become possible and the dream is that one could understand various phases of matter in terms of these combinations.

b) The strong form of the hypothesis states that particle space-time sheet can become dark. The space-time sheet of the particle would be associated with the covering $H = M^4 \times CP_2 \rightarrow H/G_a \times G_b$, where G_a and G_b are subgroups of $SU(2)$ characterizing Jones inclusions, and would be analogous to a many-sheeted Riemann surface. The large value of $\hbar$ in dark matter phase would mean that Compton lengths and -times are scaled up. A model of dark atom based on this view about darkness leads to the notion of N-atom (each sheet of the multiple covering can carry electron so that Fermi statistics apparently fails).

Nuclear string model suggests that the sizes of color flux tubes and weak flux quanta associated with nuclei can become dark in this sense and have size of order atomic radius so that dark nuclear physics would have a direct relevance for condensed matter physics. If this happens, it becomes impossible to make a reductionistic separation between nuclear physics and condensed matter physics and chemistry anymore.

2. What dark nucleons are?

The basic hypothesis is that nuclei can make a phase transition to dark phase in which the size of both quarks and nuclei is measured in Angstroms. For the less radical option this transition could happen only for the color, weak, and em field bodies. Proton connected by dark color bonds super-nuclei with inter-nucleon distance of order atomic radius might be crucial for understanding the properties of water and perhaps even the properties of ordinary condensed matter. Large $\hbar$ phase for weak field body of D and Pd nuclei with size scale of atom would explain selection rules of cold fusion.

3. Anomalous properties of water and dark nuclear physics

A direct support for partial darkness of water comes from the $H_{1.5}O$ chemical formula supported by neutron and electron diffraction in attosecond time scale. The explanation would be that one fourth of protons combine to form super-nuclei with protons connected by color bonds and having distance sufficiently larger than atomic radius.

The crucial property of water is the presence of molecular clusters. Tedrahedral clusters allow an interpretation in terms of magic Z=8 protonic dark nuclei. The icosahedral clusters consisting of 20 tedrahedral clusters in turn have interpretation as magic dark dark nuclei: the presence of the dark dark matter explains large portion of the anomalies associated with water and explains the unique role of water in biology. In living matter also higher levels of dark matter hierarchy are predicted to be present. The observed nuclear transmutation suggest that also light weak bosons are present.

4. Implications of the partial darkness of condensed matter

The model for partially dark condensed matter inspired by nuclear string model and the model of cold fusion inspired by it allows to understand the low compressibility of the condensed matter as being due to the repulsive weak force between exotic quarks, explains large parity breaking effects in living matter, and suggests a profound modification of the notion of chemical bond having most important implications for bio-chemistry and understanding of bio-chemical evolution.

1 Introduction

The unavoidable presence of classical long ranged weak (and also color) gauge fields in TGD Universe has been a continual source of worries for more than two decades. The basic question has been whether electro-weak charges of elementary particles are screened in electro-weak length scale or not. The TGD based view about dark matter assumes that weak charges are indeed screened for ordinary matter in electro-weak length scale but that dark electro-weak bosons correspond to much longer symmetry breaking length scale.

The large value of $\hbar$ in dark matter phase implies that Compton lengths and -times are scaled up. In particular, the sizes of nucleons and nuclei become of order atom size so that dark nuclear physics would have direct relevance for condensed matter physics. It becomes impossible to make a reductionistic separation between nuclear physics and condensed matter physics and chemistry anymore. This view forces a profound re-consideration of the earlier ideas in nuclear and condensed physics context. It however seems that most of the earlier ideas related to the classical Z^0 force and inspired by anomaly considerations survive in a modified form.

In its original form this chapter was an attempt to concretize and develop ideas related to dark matter by using some experimental inputs with emphasis on the predicted interaction between the new nuclear physics and condensed matter. As the vision about dark matter became more coherent and the nuclear string model developed in its recent form, it became necessary to update the chapter and throw away the obsolete material. I dare hope that the recent representation is more focused than the earlier one.

1.1 Evidence for long range weak forces and new nuclear physics

There is a lot of experimental evidence for long range electro-weak forces, dark matter, and exotic nuclear physics giving valuable guidelines in the attempts to build a coherent theoretical scenario.

1.1.1 Cold fusion

Cold fusion [61] is a phenomenon involving new nuclear physics and the known selection rules give strong constraints when one tries to understand the character of dark nuclear matter. The simplest model for cold fusion found hitherto is based on the nuclear string model [F9] and will be taken as the basis of the considerations of this chapter. Also comparisons with the earlier variant of model of cold fusion [F8] will be made in the section about cold fusion.

1.1.2 Large parity breaking effects

Large parity breaking effects in living matter indicate the presence of long ranged weak forces, and the reported nuclear transmutations in living matter [68, 69] suggest that new nuclear physics plays a role also now. For instance, the Gaussian Mersennes $(1+i)^k - 1$ for $k = 113, 151, 157163, 167$ could correspond to weak length scales and four biologically important length scales in the range 10 nm-25 μm, which seem to relate directly to the coiling hierarchy of DNA double strands. Quantum criticality of living matter against phase transitions between different values of Planck constant suggests that zeros of Riemann Zeta can appear as conformal weights of particles in living matter.

1.1.3 Anomalies of the physics of water

The physics of water involves a large number of anomalies and life depends in an essential manner on them. As many as 41 anomalies are discussed in the excellent web page "Water Structure and Behavior" of M. Chaplin [35]. The fact that the physics of heavy water differs much more from that of ordinary water as one might expect on basis of different masses of water molecules suggests that dark nuclear physics is involved.

1. The finding that one hydrogen atom per two water molecules remain effectively invisible in neutron and electron interactions in attosecond time scale [35, 36] suggests that water is partially dark. These findings have been questioned in [37] and thought to be erroneous in [38]. If the findings are real, dark matter phase made of super-nuclei consisting of protons connected by dark color bonds could explain them as perhaps also the clustering of water molecules predicting magic numbers of water molecules in clusters. If so, dark nuclear physics could be an essential part of condensed matter physics and biochemistry. For instance, the condensate of dark protons might be essential for understanding the properties of biomolecules and even the physical origin of van der Waals radius of atom in van der Waals equation of state.

2. The observation that the binding energy of dark color bond for $n = 2^{11} = 1/v_0$ of the scaling of $\hbar$ corresponds to the bond energy .5 eV of hydrogen bond raises the fascinating possibility that hydrogen bonds is accompanied by a color bond between proton and oxygen nucleus. Also more general chemical bonds might be accompanied by color bonds so that dark color physics might be an essential part of molecular physics. Color bonds might be also responsible for the formation of liquid phase and thus solid state. Dark weak bonds between nuclei could be involved and might be responsible for the repulsive core of van der Waals force and be part of molecular physics too. There is evidence for two kinds of hydrogen bonds [79, 78]: a possible identification is in terms of p-adic scaling of hydrogen bonds by a factor 2. This kind of doubling is predicted by nuclear string model [F9].

3. Tedrahedral water clusters consisting of 14 water molecules would contain 8 dark protons which corresponds to a magic number for a dark nucleus consisting of protons. Icosahedral water clusters in turn consist of 20 tedrahedral clusters. This raises the question whether fractally scaled up super-nuclei could be in question. If one accepts the vision about dark matter hierarchy based in Jones inclusions to be discussed briefly later, tedrahedral and icosahedral structures of water could correspond directly to the unique genuinely 3-dimensional $G_a = E_6$ and E_8 coverings of CP_2 with $n_a = 3$ and $n_a = 5$ assignable to dark electrons. Icosahedral structures are also very abundant in living matter, mention only viruses.

1.1.4 Exotic chemistries

Exotic chemistries [44] in which clusters of atoms of given given type mimic the chemistry of another element. These systems behave as if nuclei would form a jellium (constant charge density) defining a harmonic oscillator potential for electrons. Magic numbers correspond to full electron shells analogous to noble gas elements. It is difficult to understand why the constant charge density approximation works so well. If nuclear protons are in large $\hbar(M^4)$ phase with $n_F = 3 \times 2^{11}$, the electromagnetic sizes of nuclei would be about 2.4 Angstroms and the approximation would be natural.

As a matter, fact nuclear string model predicts that the nuclei can have as many as $3A$ exotic charge states obtained by giving neutral color bond charge ± 1: this would give rise to quite different kind of alchemy [F9] revealing itself in cold fusion.

1.1.5 Free energy anomalies

The anomalies reported by free energy researchers such as over unity energy production in devices involving repeated formation and dissociation of H_2 molecules based on the original discovery of Nobelist Irwing Langmuir [71] (see for instance [72]) suggest that part of H atoms might end up to dark matter phase liberating additional energy. The "mono-atomic" elements of Hudson suggest also dark nuclear physics [85]. There is even evidence for macroscopic transitions to dark phase [76, 77, 75].

1.1.6 Tritium beta decay anomaly and findings of Shnoll

Tritium beta decay anomaly [25, 26, 27, 28] suggests exotic nuclear physics related to weak interactions and that dark anti-neutrino density at the orbit of Earth around Sung oscillating with one year period is involved. This kind of remnant of dark matter would be consistent with the model for the formation of planets from dark matter. The evidence for the variation of the rates of nuclear and chemical processes correlating with astrophysical periods [73] could be understood in terms of weak fields created by dark matter and affect by astrophysical phenomena.

1.2 Dark rules

I have done a considerable amount of trials and errors in order to identify the basic rules allowing to understand what it means to be dark matter is and what happens in the phase transition to dark matter. It is good to try to summarize the basic rules of p-adic and dark physics allowing to avoid obvious contradictions.

1.2.1 The notion of field body

The notion of "field body" implied by topological field quantization is essential. There would be em, $Z0$, W, gluonic, and gravitonic field bodies, each characterized by its one prime. The motivation for considering the possibility of separate field bodies seriously is that the notion of induced gauge field means that all induced gauge fields are expressible in terms of four CP_2 coordinates so that only single component of a gauge potential allows a representation as and independent field quantity. Perhaps also separate magnetic and electric field bodies for each interaction and identifiable as flux quanta must be considered. This kind of separation requires that the fermionic content of the flux quantum (say fermion and anti-fermion at the ends of color flux tube) is such that it conforms with the quantum numbers of the corresponding boson.

What is interesting that the conceptual separation of interactions to various types would have a direct correlate at the level of space-time topology. From a different perspective inspired by the general vision that many-sheeted space-time provides symbolic representations of quantum physics, the very fact that we make this conceptual separation of fundamental interactions could reflect the topological separation at space-time level.

The p-adic mass calculations for quarks encourage to think that the p-adic length scale characterizing the mass of particle is associated with its electromagnetic body and in the case of neutrinos with its Z^0 body. Z^0 body can contribute also to the mass of charged particles but the contribution would be small. It is also possible that these field bodies are purely magnetic for color and weak interactions. Color flux tubes would have exotic fermion and anti-fermion at their ends and define colored variants of pions. This would apply not only in the case of nuclear strings but also to molecules and larger structures so that scaled variants of elementary particles and standard model would appear in all length scales as indeed implied by the fact that classical electro-weak and color fields are unavoidable in TGD framework.

One can also go further and distinguish between magnetic field body of free particle for which flux quanta start and return to the particle and "relative field" bodies associated with pairs of particles. Very complex structures emerge and should be essential for the understanding the space-time correlates of various interactions. In a well-defined sense they would define space-time correlate for the conceptual analysis of the interactions into separate parts. In order to minimize confusion it should be emphasized that the notion of field body used in this chapter relates to those space-time correlates of interactions, which are more or less *static* and related to the formation of *bound states*.

1.2.2 What dark variant of elementary particle means

It is not at all clear what the notion of dark variant of elementary particle or of larger structures could mean.

1. Are only field bodies dark?

One variety of dark particle is obtained by making some of the field bodies dark by increasing the value of Planck constant. This hypothesis could be replaced with the stronger assumption that elementary particles are maximally quantum critical systems so that they are same irrespective of the value of the Planck constant. Elementary particles would be represented by partonic 2-surfaces, which belong to the universal orbifold singularities remaining invariant by all groups $G_a \times G_b$ for a given choice of quantization axes. If $G_a \times G_b$ is assumed to leave invariant the choice of the quantization axes, it must be of the form $Z_{n_a} \times Z_{n_b} \subset SO(3) \times SU(3)$. Partonic 2-surface would belong to $M^2 \times CP_2/U(1) \times U(1)$, where M^2 is spanned by the quantization axis of angular momentum and the time axis defining the rest system.

A different manner to say this is that the CP_2 type extremal representing particle would suffer multiple topological condensation on its field bodies so that there would be no separate "particle space-time sheet".

Darkness would be restricted to particle interactions. The value of the Planck constant would be assigned to a particular interaction between systems rather than system itself. This conforms with the original finding that gravitational Planck constant satisfies $\hbar = GM_1M_2/v_0$, $v_0 \simeq 2^{-11}$. Since each interaction can give rise to a hierarchy dark phases, a rich variety of partially dark phases is predicted. The standard assumption that dark matter is visible only via gravitational interactions would mean that gravitational field body would not be dark for this particular dark matter.

Complex combinations of dark field bodies become possible and the dream is that one could understand various phases of matter in terms of these combinations. All phase transitions, including the familiar liquid-gas and solid-liquid phase transitions, could have a unified description in terms of dark phase transition for an appropriate field body. At mathematical level Jones inclusions would provide this description.

The book metaphor for the interactions at space-time level is very useful in this framework. Elementary particles correspond to ordinary value of Planck constant analogous to the ordinary sheets of a book and the field bodies mediating their interactions are the same space-time sheet or at dark sheets of the book.

2. Can also elementary particles be dark?

Also dark elementary particles themselves rather than only the flux quanta could correspond to dark space-time sheet defining multiple coverings of $H/G_a \times G_b$. This would mean giving up the maximal quantum criticality hypothesis in the case of elementary particles. These sheets would be exact copies of each other. If single sheet of the covering contains topologically condensed space-time sheet, also other sheets contain its exact copy.

The question is whether these copies of space-time sheet defining classical identical systems can carry different fermionic quantum numbers or only identical fermionic quantum numbers so that the dark particle would be exotic many-fermion system allowing an apparent violation of statistics (N fermions in the same state).

Even if one allows varying number of fermions in the same state with respect to a basic copy of sheet, one ends up with the notion of N-atom in which nuclei would be ordinary but electrons would reside at the sheets of the covering. The question is whether symbolic representations essential for understanding of living matter could emerge already at molecular level via the formation of N-atoms.

1.2.3 Criterion for the transition to dark phase

The criterion $\alpha Q_1 Q_2 > 1$ for the transition to dark matter phase relates always to the interaction between two systems and the interpretation is that when the field strength characterizing the interaction becomes too strong, the interaction is mediated by dark space-time sheets which define $n = n(G_a) \times n(G_b)$-fold covering of $M^4 \times CP_2/G_a \times G_b$. The sharing of flux between different space-time sheets reduces the field strength associated with single sheet below the critical value.

1.3 Implications

1.3.1 Dark variants of nuclear physics

One can imagine endless variety of dark variants of ordinary nuclei and every piece of data is well-come in attempts to avoid a complete inflation of speculative ideas. The book metaphor for the extended imbedding space is useful in the attempts to imagine various exotic phases of matter. For the minimal option atomic nuclei would be ordinary whereas field bodies could be dark and analogous to n-sheeted Riemann surfaces. One can imagine that the nuclei are at the "standard" page of the book and color bonds at different page with different p-adic length scale or having different Planck constant $\hbar_{eff}$. This would give two hierarchies of nuclei with increasing size.

Color magnetic body of the structure would become a key element in understanding the nuclear binding energies, giant dipole resonances, and nuclear decays. Also other field bodies are in a key role and there seems to be a field body for every basic interaction (classical gauge fields are induced from spinor connection and only four independent field variables are involved so that this is indeed required).

Nothing prevents from generalizing the nuclear string picture so that color bonds could bind also atoms to molecules and molecules to larger structures analogous to nuclei. Even hydrogen bond might be interpreted in this manner. Molecular physics could be seen as a scaled up variant of nuclear physics in a well-defined sense. The exotic features would relate to the hierarchy of various field bodies, including color bonds, electric and weak bonds. These field bodies would play key role also in biology and replaced molecular randomness with coherence in much longer length scale.

In the attempt to make this vision quantitative the starting point is nuclear string model [F9] and the model of cold fusion based on it forcing also to conclude the scaled variants of electro-weak bosons are involved. The model of cold fusion requires the presence of a variant electro-weak interactions for which weak bosons are effectively massless below the atomic length scale. $k = 113$ p-adically scaled up variant of ordinary weak bosons which is dark and corresponds to $\hbar = n\hbar_0$, $n = 2^{11}$, is a natural option. For ordinary nuclei weak bosons could be ordinary.

Anomalies of water could be understood if one assumes that color bonds can become dark with $n = k2^{11}$, $k = 1, 3$ and if super-nuclei formed by connecting different nuclei by the color bonds are possible. Tetrahedral and icosahedral water clusters could be seen as magic super-nuclei in this framework. Color bonds could connect either proton nuclei or water molecules.

1.3.2 Could the notion of dark atom make sense?

One can also imagine several variants of dark atom. Book metaphor suggest one variant of dark atom.

1. Nuclei and electrons could be ordinary but classical electromagnetic interactions are mediated via dark space-time sheet "along different page of the book". The value of Planck constant would be scaled so that one would obtain a hierarchy of scaled variants of hydrogen atom. The findings of Mills [82] find an explanation in terms of a reduced Planck constant. An alternative explanation is based on the notion of quantum-hydrogen atom obtained as q-deformation of the ordinary hydrogen atom.

2. A more exotic variant if atom is obtained by assuming ordinary nuclei but dark, not totally quantum critical, electrons. Dark space-time surface is analogous to n-sheeted Riemann surface and if one assumes that each sheet could carry electron, one ends up with the notion of N-atom.

1.3.3 Implications of the partial darkness of condensed matter

The model for partially dark condensed matter deriving from nuclear physics allows to understand the low compressibility of the condensed matter as being due to the repulsive weak force between exotic quarks, explains large parity breaking effects in living matter, and suggests a profound modification of the notion of chemical bond having most important implications for bio-chemistry and understanding of bio-chemical evolution.

2 General ideas about dark matter

In the sequel general ideas about the role of dark matter in condensed matter physics are described.

2.1 Quantum criticality, hierarchy of dark matters, and dynamical $\hbar$

Quantum criticality is the basic characteristic of TGD Universe and quantum critical superconductors provide an excellent test bed to develop the ideas related to quantum criticality into a more concrete form.

2.1.1 Quantization of Planck constants and the generalization of the notion of imbedding space

The recent geometric interpretation for the quantization of Planck constants is based on Jones inclusions of hyper-finite factors of type II_1 [A9].

1. Different values of Planck constant correspond to imbedding space metrics involving scalings of M^4 *resp.* CP_2 parts of the metric deduced from the requirement that distances scale as $\hbar(M^4)$ *resp.* $\hbar(M^4)$. Denoting the Planck constants by $\hbar(M^4) = n_a\hbar_0$ and $\hbar(CP_2) = n_b\hbar_0$, one has that covariant metric of M^4 is proportional to n_b^2 and covariant metric of CP_2 to n_a^2. In Kähler action only the effective Planck constant $\hbar_{eff}/\hbar_0 = \hbar(M^4)/\hbar(CP_2)$ appears and by quantum classical correspondence same is true for Schödinger equation. Elementary particle mass spectrum is also invariant. Same applies to gravitational constant. The alternative assumption that M^4 Planck constant is proportional to n_b would imply

invariance of Schrödinger equation but would not allow to explain Bohr quantization of planetary orbits and would to certain degree trivialize the theory.

2. M^4 and CP_2 Planck constants do not fully characterize a given sector $M^4_\pm \times CP_2$. Rather, the scaling factors of Planck constant given by the integer n characterizing the quantum phase $q = exp(i\pi/n)$ corresponds to the order of the maximal cyclic subgroup for the group $G \subset SU(2)$ characterizing the Jones inclusion $\mathcal{N} \subset \mathcal{M}$ of hyper-finite factors realized as subalgebras of the Clifford algebra of the "world of the classical worlds". This means that subfactor $\mathcal{N}$ gives rise to G-invariant configuration space spinors having interpretation as G-invariant fermionic states.

3. $G_b \subset SU(2) \subset SU(3)$ defines a covering of M^4_+ by CP_2 points and $G_a \subset SU(2) \subset SL(2,C)$ covering of CP_2 by M^4_+ points with fixed points defining orbifold singularities. Different sectors are glued together along CP_2 if G_b is same for them and along M^4_+ if G_a is same for them. The degrees of freedom lost by G-invariance in fermionic degrees of freedom are gained back since the discrete degrees of freedom provided by covering allow many-particle states formed from single particle states realized in G group algebra. Among other things these many-particle states make possible the notion of N-atom.

4. Phases with different values of scalings of M^4 and CP_2 Planck constants behave like dark matter with respect to each other in the sense that they do not have direct interactions except at criticality corresponding to a leakage between different sectors of imbedding space glued together along M^4 or CP_2 factors. In large $\hbar(M^4)$ phases various quantum time and length scales are scaled up which means macroscopic and macro-temporal quantum coherence. In particular, quantum energies associated with classical frequencies are scaled up by a factor n_a/n_b which is of special relevance for cyclotron energies and phonon energies (superconductivity). For large $\hbar(CP_2)$ the value of $\hbar_{eff}$ is small: this leads to interesting physics: in particular the binding energy scale of hydrogen atom increases by the factor n_b/n_a^2.

2.1.2 A further generalization of the notion of imbedding space

The original idea was that the proposed modification of the imbedding space could explain naturally phenomena like quantum Hall effect involving fractionization of quantum numbers like spin and charge. This does not however seem to be the case. $G_a \times G_b$ implies just the opposite if these quantum numbers are assigned with the symmetries of the imbedding space. For instance, quantization unit for orbital angular momentum becomes n_a where Z_{n_a} is the maximal cyclic subgroup of G_a.

One can however imagine of obtaining fractionization at the level of imbedding space for space-time sheets, which are analogous to multi-sheeted Riemann surfaces (say Riemann surfaces associated with $z^{1/n}$ since the rotation by 2π understood as a homotopy of M^4 lifted to the space-time sheet is a non-closed curve. Continuity requirement indeed allows fractionization of the orbital quantum numbers and color in this kind of situation.

1. Both covering spaces and factor spaces are possible

The observation above stimulates the question whether it might be possible in some sense to replace H or its factors by their multiple coverings.

1. This is certainly not possible for M^4, CP_2, or H since their fundamental groups are trivial. On the other hand, the fixing of quantization axes implies a selection of the sub-space $H_4 = M^2 \times S^2 \subset M^4 \times CP_2$, where S^2 is a geodesic sphere of CP_2. $\hat{M}^4 = M^4 \backslash M^2$ and $\hat{CP}_2 = CP_2 \backslash S^2$ have fundamental group Z since the codimension of the excluded sub-manifold is

equal to two and homotopically the situation is like that for a punctured plane. The exclusion of these sub-manifolds defined by the choice of quantization axes could naturally give rise to the desired situation.

2. There are two geodesic spheres in CP_2. Which one should choose or are both possible?

   i) For the homologically non-trivial one corresponding to cosmic strings, the isometry group is $SU(2) \subset SU(3)$. The homologically trivial one S^2 corresponds to vacuum extremals and has isometry group $SO(3) \subset SU(3)$. The natural question is which one should choose. At quantum criticality the value of Planck constant is undetermined. The vacuum extremal would be a natural choice from the point of view of quantum criticality since in this case the value of Planck constant does not matter at all and one would obtain a direct connection with the vacuum degeneracy.

   One can of course ask whether all surfaces $M^2 \times Y^2$, Y^2 Lagrangian sub-manifold of CP_2 defining vacuum sectors of the theory should be allowed. The answer seems to be "No" since in the generic case $SO(3)$ does not act as H-isometries of Y^2. If one allows these sub-manifolds or even sub-manifolds of form $M^4 \times Y^2$ to appear as intersection of fractally scaled up variants, one must replace Cartan algebra as algebra associated with $SO(3)$ subgroup of canonical transformations of CP_2 mapping Y^2 to itself (if this kind of algebra exists).

   ii) The choice of the homologically non-trivial geodesic sphere as a quantum critical sub-manifold would conform with the previous guess that $\mathcal{M} : \mathcal{N} = 4$ corresponds to cosmic strings. It is however questionable whether the ill-definedness of the Planck constant is consistent with the non-vacuum extremal property of cosmic strings unless one assumes that for partonic 3-surfaces $X^3 \subset M^2 \times S^2$ the effective degrees of freedom reduce to mere topological ones.

3. The covering spaces in question would correspond to the Cartesian products $\hat{M^4}_{n_a} \times \hat{CP_2}_{n_b}$ of the covering spaces of $\hat{M}^4$ and $\hat{CP_2}$ by Z_{n_a} and Z_{n_b} with fundamental group is $Z_{n_a} \times Z_{n_b}$. One can also consider extension by replacing M^2 and S^2 with its orbit under G_a (say tedrahedral, octahedral, or icosahedral group). The resulting space will be denoted by $\hat{M}^4 \hat{\times} G_a$ *resp.* $\hat{CP_2} \hat{\times} G_b$.

4. One expects the discrete subgroups of $SU(2)$ emerge naturally in this framework if one allows the action of these groups on the singular sub-manifolds M^2 or S^2. This would replace the singular manifold with a set of its rotated copies in the case that the subgroups have genuinely 3-dimensional action (the subgroups which corresponds to exceptional groups in the ADE correspondence). For instance, in the case of M^2 the quantization axes for angular momentum would be replaced by the set of quantization axes going through the vertices of tedrahedron, octahedron, or icosahedron. This would bring non-commutative homotopy groups into the picture in a natural manner.

5. Also the orbifolds $\hat{M}^4/G_a \times \hat{CP_2}/G_b$ can be allowed as also the spaces $\hat{M}^4/G_a \times (\hat{CP_2} \hat{\times} G_b)$ and $(\hat{M}^4 \hat{\times} G_a) \times \hat{CP_2}/G_b$. Hence the previous framework would generalize considerably by the allowance of both coset spaces and covering spaces.

There are several non-trivial questions related to the details of the gluing procedure and phase transition as motion of partonic 2-surface from one sector of the imbedding space to another one.

1. How the gluing of copies of imbedding space at $M^2 \times CP_2$ takes place? It would seem that the covariant metric of M^4 factor proportional to $\hbar^2$ must be discontinuous at the singular manifold since only in this manner the idea about different scaling factor of M^4 metric can make sense. This is consistent with the identical vanishing of Chern-Simons action in $M^2 \times S^2$.

2. One might worry whether the phase transition changing Planck constant means an instantaneous change of the size of partonic 2-surface in M^4 degrees of freedom. This is not the case. Light-likeness in $M^2 \times S^2$ makes sense only for surfaces $X^1 \times D^2 \subset M^2 \times S^2$, where X^1 is light-like geodesic. The requirement that the partonic 2-surface X^2 moving from one sector of H to another one is light-like at $M^2 \times S^2$ irrespective of the value of Planck constant requires that X^2 has single point of M^2 as M^2 projection. Hence no sudden change of the size X^2 occurs.

3. A natural question is whether the phase transition changing the value of Planck constant can occur purely classically or whether it is analogous to quantum tunnelling. Classical non-vacuum extremals of Chern-Simons action have two-dimensional CP_2 projection to homologically non-trivial geodesic sphere S^2_I. The deformation of the entire S^2_I to homologically trivial geodesic sphere S^2_{II} is not possible so that only combinations of partonic 2-surfaces with vanishing total homology charge (Kähler magnetic charge) can in principle move from sector to another one, and this process involves fusion of these 2-surfaces such that CP_2 projection becomes single homologically trivial 2-surface. A piece of a non-trivial geodesic sphere S^2_I of CP_2 can be deformed to that of S^2_{II} using 2-dimensional homotopy flattening the piece of S^2 to curve. If this homotopy cannot be chosen to be light-like, the phase transitions changing Planck constant take place only via quantum tunnelling. Obviously the notions of light-like homotopies (cobordisms) and classical light-like homotopies (cobordisms) are very relevant for the understanding of phase transitions changing Planck constant.

2. Do factor spaces and coverings correspond to the two kinds of Jones inclusions?

What could be the interpretation of these two kinds of spaces?

1. Jones inclusions appear in two varieties corresponding to $\mathcal{M} : \mathcal{N} < 4$ and $\mathcal{M} : \mathcal{N} = 4$ and one can assign a hierarchy of subgroups of $SU(2)$ with both of them. In particular, their maximal Abelian subgroups Z_n label these inclusions. The interpretation of Z_n as invariance group is natural for $\mathcal{M} : \mathcal{N} < 4$ and it naturally corresponds to the coset spaces. For $\mathcal{M} : \mathcal{N} = 4$ the interpretation of Z_n has remained open. Obviously the interpretation of Z_n as the homology group defining covering would be natural.

2. $\mathcal{M} : \mathcal{N} = 4$ should correspond to the allowance of cosmic strings and other analogous objects. Does the introduction of the covering spaces bring in cosmic strings in some controlled manner? Formally the subgroup of $SU(2)$ defining the inclusion is $SU(2)$ would mean that states are $SU(2)$ singlets which is something non-physical. For covering spaces one would however obtain the degrees of freedom associated with the discrete fiber and the degrees of freedom in question would not disappear completely and would be characterized by the discrete subgroup of $SU(2)$.

   For anyons the non-trivial homotopy of plane brings in non-trivial connection with a flat curvature and the non-trivial dynamics of topological QFTs. Also now one might expect similar non-trivial contribution to appear in the spinor connection of $\hat{M}^2 \hat{\times} G_a$ and $\hat{CP}_2 \hat{\times} G_b$. In conformal field theory models non-trivial monodromy would correspond to the presence of punctures in plane.

3. For factor spaces the unit for quantum numbers like orbital angular momentum is multiplied by n_a *resp.* n_b and for coverings it is divided by this number. These two kind of spaces are in a well defined sense obtained by multiplying and dividing the factors of $\hat{H}$ by G_a *resp.* G_b and multiplication and division are expected to relate to Jones inclusions with $\mathcal{M} : \mathcal{N} < 4$ and $\mathcal{M} : \mathcal{N} = 4$, which both are labelled by a subset of discrete subgroups of SU(2).

4. The discrete subgroups of $SU(2)$ with fixed quantization axes possess a well defined multiplication with product defined as the group generated by forming all possible products of group elements as elements of $SU(2)$. This product is commutative and all elements are idempotent and thus analogous to projectors. Trivial group G_1, two-element group G_2 consisting of reflection and identity, the cyclic groups Z_p, p prime, and tedrahedral, octahedral, and icosahedral groups are the generators of this algebra.

   By commutativity one can regard this algebra as an 11-dimensional module having natural numbers as coefficients ("rig"). The trivial group G_1, two-element group G_2¡ generated by reflection, and tedrahedral, octahedral, and icosahedral groups define 5 generating elements for this algebra. The products of groups other than trivial group define 10 units for this algebra so that there are 11 units altogether. The groups Z_p generate a structure analogous to natural numbers acting as analog of coefficients of this structure. Clearly, one has effectively 11-dimensional commutative algebra in 1-1 correspondence with the 11-dimensional "half-lattice" N^{11} (N denotes natural numbers). Leaving away reflections, one obtains N^7. The projector representation suggests a connection with Jones inclusions. An interesting question concerns the possible Jones inclusions assignable to the subgroups containing infinitely manner elements. Reader has of course already asked whether dimensions 11, 7 and their difference 4 might relate somehow to the mathematical structures of M-theory with 7 compactified dimensions: why should 11-D discrete momentum lattice correspond to the lattice of subgroups of SU(2)? One could introduce generalized configuration space spinor fields in the configuration space labelled by sectors of H with given quantization axes. By introducing Fourier transform in N^{11} one would formally obtain an infinite-component field in 11-D space. Both M^4 and CP_2 would give this kind of factor and together with space-time dimension this would give $D = 26$.

5. How do the Planck constants associated with factors and coverings relate? One might argue that Planck constant defines a homomorphism respecting the multiplication and division (when possible) by G_i. If so, then Planck constant in units of $\hbar_0$ would be equal to n_a/n_b for $\hat{H}/G_a \times G_b$ option and n_b/n_a for $\hat{H}\hat{\times}(G_a \times G_b)$ with obvious formulas for the hybrid cases. This option puts M^4 and CP_2 in a very symmetric role and allows much more flexibility in the identification of symmetries associated with large Planck constant phases.

3. Fractional Quantum Hall Effect

The generalization of the imbedding space allows to understand fractional quantum Hall effect [55]. The formula for the quantized Hall conductance is given by

$$\begin{aligned} \sigma &= \nu \times \frac{e^2}{h} \ , \\ \nu &= \frac{n}{m} \ . \end{aligned} \tag{1}$$

Series of fractions in $\nu = 1/3, 2/5, 3/7, 4/9, 5/11, 6/13, 7/15..., 2/3, 3/5, 4/7, 5/9, 6/11, 7/13..., 5/3, 8/5, 11/7, 14/9...4/$ $1/5, 2/9, 3/13..., 2/7, 3/11..., 1/7....$ with odd denominator have been observed as are also $\nu = 1/2$ and $\nu = 5/2$ states with even denominator [55].

The model of Laughlin [53, 54] cannot explain all aspects of FQHE. The best existing model proposed originally by Jain is based on composite fermions resulting as bound states of electron and even number of magnetic flux quanta [56]. Electrons remain integer charged but due to the effective magnetic field electrons appear to have fractional charges. Composite fermion picture predicts all the observed fractions and also their relative intensities and the order in which they appear as the quality of sample improves.

In [E9] I have proposed a possible TGD based model of FQHE not involving hierarchy of Planck constants. The generalization of the notion of imbedding space suggests also the possibility to interpret these states in terms of fractionized charge and electron number.

1. The easiest manner to understand the observed fractions is by assuming that both M^4 and CP_2 correspond to covering spaces so that both spin and electric charge and fermion number are quantized. With this assumption the expression for the Planck constant becomes $\hbar/\hbar_0 = n_b/n_a$ and charge and spin units are equal to $1/n_b$ and $1/n_a$ respectively. This gives $\nu = nn_a/n_b^2$. The values $m = 2, 3, 5, 7, ..$ are observed. Planck constant can have arbitrarily large values. There are general arguments stating that also spin is fractionized in FQHE and for $n_a = kn_b$ required by the observed values of ν charge fractionization occurs in units of k/n_b and forces also spin fractionization. For factor space option in M^4 degrees of freedom one would have $\nu = n/n_a n_b^2$.

2. The appearance of $n_b = 2$ would suggest that also Z_2 appears as the homotopy group of the covering space: filling fraction $1/2$ corresponds in the composite fermion model and also experimentally to the limit of zero magnetic field [56]. Also $\nu = 5/2$ has been observed [57].

3. A possible problematic aspect of the TGD based model is the experimental absence of even values of n_b except $n_b = 2$. A possible explanation is that by some symmetry condition possibly related to fermionic statistics kn/n_b must reduce to a rational with an odd denominator for $n_b > 2$. In other words, one has $k \propto 2^r$, where 2^r the largest power of 2 divisor of n_b smaller than n_b.

4. Large values of n_b emerge as B increases. This can be understood from flux quantization. One has $eBS = n\hbar = n(n_b/n_a)\hbar_0$. The interpretation is that each of the n_b sheets contributes n/n_a units to the flux. As B increases also the flux increases for a fixed value of n_a and area S. Note that the value of magnetic field in given sheet is not affected so that the build-up of multiple covering seems to keep magnetic field strength below critical value. For $n_a = kn_b$ one obtains $eBS/\hbar_0 = n/k$ so that a fractionization of magnetic flux results and each sheet contributes $1/kn_b$ units to the flux. $\nu = 1/2$ corresponds to $k = 1, n_b = 2$ and to non-vanishing magnetic flux unlike in the case of composite fermion model.

5. The understanding of the thermal stability is not trivial. The original FQHE was observed in 80 mK temperature corresponding roughly to a thermal energy of $T \sim 10^{-5}$ eV. For graphene the effect is observed at room temperature. Cyclotron energy for electron is (from $f_e = 6 \times 10^5$ Hz at $B = .2$ Gauss) of order thermal energy at room temperature in a magnetic field varying in the range 1-10 Tesla. This raises the question why the original FQHE requires so low temperature. The magnetic energy of a flux tube of length L is by flux quantization roughly $e^2B^2S \sim E_c(e)m_eL$ ($\hbar_0 = c = 1$) and exceeds cyclotron roughly by a factor L/L_e, L_e electron Compton length so that thermal stability of magnetic flux quanta is not the explanation. A possible explanation is that since FQHE involves several values of Planck constant, it is quantum critical phenomenon and is characterized by a critical temperature. The differences of the energies associated with the phase with ordinary Planck constant and phases with different Planck constant would characterize the transition temperature.

2.2 How the scaling of $\hbar$ affects physics and how to detect dark matter?

It is relatively easy to deduce the basic implications of the scaling of $\hbar$.

1. If the rate for the process is non-vanishing classically, it is not affected in the lowest order. For instance, scattering cross sections for say electron-electron scattering and e^+e^- annihilation

are not affected in the lowest order since the increase of Compton length compensates for the reduction of α_{em}. Photon-photon scattering cross section, which vanishes classically and is proportional to $\alpha_{em}^4\hbar^2/E^2$, scales down as $1/\hbar^2$.

2. Higher order corrections coming as powers of the gauge coupling strength α are reduced since $\alpha = g^2/4\pi\hbar$ is reduced. Since one has $\hbar_s/\hbar = \alpha Q_1 Q_2/v_0$, $\alpha Q_1 Q_2$ is effectively replaced with a universal coupling strength v_0. In the case of QCD the paradoxical sounding implication is that α_s would become very small.

3. The binding energy scale $E \propto \alpha_{em}^2 m_e$ of atoms scales as $1/\hbar^2$. This would suggest that a partially dark matter for which protons have a large value of $\hbar(M^4)$ does not interact appreciably with the ordinary light. Multiple coverings defined by G_a and G_b imply fractionization of various quantum numbers as $q \rightarrow q/n_a$ for CP_2 quantum numbers and as $n \rightarrow q/n_b$ for spin. One prediction is N-atom for which the $N = N(G_b)$ sheets of covering of M^4_+ can carry up to N electrons with identical quantum numbers. In this case Planck constant is scaled down by n_a/n_b so that the scale of hydrogen atom binding energy increases by $k^2 = (n_b/n_a)^2$. Mills reports this kind of scalings for $k = 2, 3, ..., 10$ [82]. Dark positive charges are however required to stabilize the electronic charge but the example of atomic nuclei suggests that N-atoms can be stable.

2.3 General view about dark matter hierarchy and interactions between relatively dark matters

The identification of the precise criterion characterizing dark matter phase is far from obvious. TGD actually suggests an infinite number of phases which are dark relative to each other in some sense and can transform to each other only via a phase transition which might be called de-coherence or its reversal and which should be also characterized precisely.

A possible solution of the problem comes from the general construction recipe for S-matrix. Fundamental vertices correspond to partonic 2-surfaces representing intersections of incoming and outgoing light-like partonic 3-surfaces.

1. If the characterization of the interaction vertices involves all points of partonic 2-surfaces, they must correspond to definite value of Planck constants and more precisely, definite groups G_a and G_b characterizing dark matter hierarchy. Particles of different G_b phases could not appear in the same vertex since the partons in question would correspond to vacuum extremals. Hence the phase transition changing the particles to each other analogous could not be described by a vertex and would be analogous to a de-coherence.

   The phase transition could occur at the incoming or outgoing particle lines. At space-time level the phase transition would mean essentially a leakage between different sectors of imbedding space and means that partonic 2-surface at leakage point has CP_2 projection reducing to the orbifold point invariant under G or alternatively, its $M^4_\pm$ projection corresponds to the tip of $M^4_\pm$. Relative darkness would certainly mean different groups G_a and G_b. Note that $\hbar(M^4)$ *resp.* $\hbar(CP_2)$ can be same for different groups G_a *resp.* G_b and that only the ratio of $\hbar(M^4)/\hbar(M^4)$ appears in the Kähler action.

2. One can represent a criticism against the idea that relatively dark matters cannot appear at the same interaction vertex. The point is that the construction of S-matrix for transitions transforming partonic 2-surfaces in different number fields involves only the rational (algebraic) points in the intersection of the 2-surfaces in question. This idea applies also to the case in which particles correspond to different values of Planck constant. What is only needed that all the common points correspond to the orbifold point in M^4 or CP_2 degrees

of freedom and are thus intermediate between two sectors of imbedding space. In this picture phase transitions would occur through vertices and S-matrix would characterize their probabilities. It seems that this option is the correct one.

If the matrix elements for real-real transitions involve all or at least a circle of the partonic 2-surface as stringy considerations suggest [C2], then one would have clear distinction between quantum phase transitions and ordinary quantum transitions. Note however that one could understand the weakness of the quantal interactions between relatively dark matters solely from the fact that the CP_2 type extremals providing space-time correlates for particle propagators must in this case go through an intermediate state with at most point-like CP_2 projection.

At quantum level the phase transition is possible only at quantum criticality and number theoretic considerations lead to the hypothesis that super-canonical conformal weights for partons reduce to zeros of Riemann Zeta in this situation. In the general case the imaginary parts of conformal weights would be linear combinations $y = \sum_k n_k y_k$ of imaginary parts of zeros $1/2 + iy_k$ of ζ with integer coefficients.

2.3.1 What does one mean with dark variants of elementary particle?

It is not at all clear what one means with the dark variant of elementary particle. In this respect p-adic mass calculations provide a valuable hint. According to the p-adic mass calculations [F4], $k = 113$ characterizes electromagnetic size of u and d quarks, of nucleons, and nuclei. $k = 107$ characterizes the QCD size of hadrons. This is somewhat paradoxical situation since one would expect that quark space-time sheets would be smaller than hadronic space-time sheets.

The simplest resolution of the problem suggested by the basic characteristics of electro-weak symmetry breaking is that $k = 113$ characterizes the size of the electro-magnetic field body of the quark and that the prime characterizing p-adic mass scale labels the em field body of the particle. One can assign mass also the Z^0 body but this would be much smaller as the small scale of neutrino masses suggests. This size scale correspond to a length scale of order 10 μm, which conforms with the expectation that classical Z^0 force is important in biological length scales. The size of Z^0 body of neutrino could relate directly to the chirality selection in living matter. An interesting question is whether the Z^0 field bodies of also other elementary fermions are of this size.

If this picture is correct then dark variant of elementary particle would differ from ordinary only in the sense that its field body would be dark. This conforms with the general working hypothesis is that only field bodies can be dark.

2.3.2 Are particles characterized by different p-adic primes relatively dark?

Each particle is characterized by a collection of p-adic primes corresponding to the partonic 2-surfaces associate with the particle like 3-surface. Number theoretical vision supports the notion of multi-p p-adicity and the idea that elementary particles correspond to infinite primes, integers, or perhaps even rationals [E3, F6]. To infinite primes, integers, and rationals it is possible to associate a finite rational $q = m/n$ by a homomorphism. This would suggest generalization of p-adicity with q-adicity (q-adic topology does not correspond to number field) but this does not seem to be a promising idea.

The crucial observation is that one can decompose the infinite prime, call it P, to finite and infinite parts and distinguish between bosonic and fermionic finite primes of which infinite prime can be said to consist of [C6, E3, H8]. The interpretation is that bosonic and fermionic finite primes in the *infinite* part of P code for p-adic topologies of light-like partonic 3-surfaces associated with a given *real* space-time sheet whereas the primes in the *finite* part of P code for p-adic lightlike partonic 3-surfaces.

This raises two options.

1. Two space-time sheets characterized by rationals having common prime factors can be connected by a $\#_B$ contact and can interact by the exchange of particles characterized by divisors of m or n since in this case partonic 2-surface with same p-adic or effective p-adic topology can be found. This is the only possible interaction between them.

2. The number theoretic vision about the construction of S-matrix however allows to construct S-matrix also in the case that partons belong to different number fields and one ends up with a very elegant description involving only finite number of points of partonic 2-surfaces belonging to their intersection consisting of rational (algebraic points of imbedding space), which by algebraic universality could apply also to diagonal transitions. Also now the interactions mediated between propagators connecting partons with different effective p-adic topologies might be very slow so that this would give rise to relative darkness.

2.3.3 Interpretation of super-canonical conformal weights

Super-canonical conformal weights [B3, C1] are in general complex and define a new kind, perhaps even conserved, quantum number which could be called scaling momentum. There are strong number theoretic reasons to believe that the conformal weights are expressible in terms of zeros of Riemann Zeta.

1. Generalization of the notion of super-canonical conformal weight, p-adicization, and number theoretical universality of Riemann Zeta

It has clear that super-canonical conformal weights could actually depend on the CP_2 of the partonic 2-surface via the formula $\Delta = \zeta^{-1}(z)$, where z is the complex coordinate of the projection of the point of partonic to the geodesic sphere of CP_2 transforming linearly under $U(2) \subset SU(3)$. Note that Δ has infinite number of branches corresponding to the zeros of ζ, and the region of partonic 2-surface given branch generalizes the notion of constant conformal weight. Several branches can be associated with a given partonic 2-surface.

In the most general case Δ could be sum of $\delta M^4_\pm$ and CP_2 parts where M^4_+ part is of same form but now argument corresponds to the standard projective complex coordinate of S^2. Also now orbifold points would be introduced and the interpretation would be in terms of a selection of the quantization direction of angular momentum occurring already at the level of configuration space of 3-surfaces.

Suppose that one accepts the hypothesis of the number theoretical universality of ζ stating that the zeros $s_k = 1/2 + iy_k$ of ζ have the property that the factors $1/(1 + p^{s_k}$ are algebraic numbers for all zeros of zeta [C1, E8]. This is guaranteed if p^{iy_k} is algebraic number for any value of p and y_k. Under this assumption, p-adicization requires that the intersections of partonic 2-surfaces belonging to different number fields must correspond to points which are linear combinations of zeros of ζ with integer coefficients. Zeros of Riemann Zeta in turn correspond to orbifold points which are common to the sectors of the imbedding space characterized by different groups G_b and thus possessing different values of $\hbar(M^4)$ in general.

This means that a collection of super-canonical conformal weights can be associated with the intersection points of real parton surface with a given effective p-adic topology and that each value of conformal weight defines a number theoretic braid. Same applies to the intersections of partonic space-time sheets with different p-adic topologies. The sum of these conformal weights associated with the interaction points can be said to define the net super-canonical conformal weight of the particle. Obviously super-canonical conformal weights do not define quantum number in the standard sense of the word. In particular, the new effective quantum number does not allow an effective violation of Fermi statistics.

What is important that conformal weights associated with the quantum critical partonic 2-surface must correspond to zeros or infinite values of Riemann Zeta for quantum critical points since these points correspond to north and south poles of ζ remaining invariant under G_b.

2. Is conformal confinement needed?

The first guess was that the net value of super-canonical conformal weight is real for physical states. This would give rise to the notion of conformal confinement. It was thought that a particular kind of dark matter would correspond to a conformally confined matter with particles having complex conformal weights such that the net conformal weight is real. The proposed identification of the net super-canonical conformal weight does not support this identification.

It has also become clear that there is no strong physical reason to require the reality of conformal weights at single particle level [C1]: in zero energy ontology the reality of the net conformal weight for zero energy states is predicted in any case since all conserved quantum numbers vanish for them. Furthermore, the conjugation of the conformal weight has interpretation as generalization of phase conjugation of photons in laser physics. This means that time orientation becomes an inherent characteristic of a particle so that positive energy particles propagating in the direction of the geometric future can be distinguished from negative energy particles propagating to the direction of the geometric past.

3. Bound states and zeros of polyzetas

Also bound many-particle states must be considered. In [C5] I introduced the notion of bound state conformal weight generalizing the notion of binding energy. The zeros of polyzetas generalizing Riemann Zeta to functions of N complex arguments define a candidate for the building blocks of complex conformal weights of N-particle bound states at the first level of the hierarchy and perhaps also at higher levels of hierarchy. It turns out that number theoretical constraints imply that total bound state conformal weights are of precisely same form as single particle conformal weights and that only 2- and 3-particle bounds states are non-trivial suggesting very strongly an interpretation in terms of mesons and baryons [C1].

2.3.4 Hierarchy of infinite primes and dark matter hierarchy

In previous consideration only the simplest infinite primes at the lowest level of hierarchy were considered. Simple infinite primes allow a symmetry changing the sign of the finite part of infinite prime. A possible interpretation in terms of phase conjugation. One can consider also more complex infinite primes at this level and a possible interpretation in terms of bound states of several particles. One can also consider infinite integers and rationals: the interpretation would be as many particle states. Rationals might correspond to states containing particles and antiparticles. At the higher levels of the hierarchy infinite primes of previous take the role of finite primes at the previous level and physically these states correspond to higher level bound states of the particles of the previous level.

Thus TGD predicts an entire hierarchy of dark matters such that the many particle states at previous level become particles at the next level. This hierarchy would provide a concrete physical identification for the hierarchy of infinite primes identifiable in terms of a repeated second quantization of an arithmetic super-symmetric QFT [E3] including both free many-particle states and their bound states. The finite primes about which infinite prime is in a well defined sense a composite of would correspond to the particles in the state forming a unit of dark matter. Particles belonging to different levels of this hierarchy would obviously correspond to different levels of dark matter hierarchy but their interactions must reduce to the fundamental partonic vertices.

2.4 How dark matter and visible matter interact?

The hypothesis that the value of $\hbar$ is dynamical, quantized and becomes large at the verge of a transition to a non-perturbative phase in the ordinary sense of the word has fascinating implications. In particular, dark matter, would correspond to a large value of $\hbar$ and could be responsible for the properties of the living matter. In order to test the idea experimentally, a more concrete model for the interaction of ordinary matter and dark matter must be developed and here of course experimental input and the consistency with the earlier quantum model of living matter is of considerable help.

2.4.1 How dark photons transform to ordinary photons?

The transitions of dark atoms naturally correspond to coherent transitions of the entire dark electron BE condensate and thus generate N_{cr} dark photons and behave thus like laser beams. Dark photons do not interact directly with the visible matter. An open question is whether even ordinary laser beams could be identified as beams of dark photons: the multiple covering property at the level of imbedding space and the fact that MEs are possible in all sectors suggests that this is not the case. Note that the transition from dark to ordinary photons implies the scaling of wave length and thus also of coherence length by a factor n_b/n_a.

Dark $\leftrightarrow$ visible transition should have also a space-time correlate. The so called topological light rays or MEs ("massless extremals") represent a crucial deviation of TGD from Maxwell's ED and have all the properties characterizing macroscopic classical coherence. Therefore MEs are excellent candidates for the space-time correlate of BE condensate of dark photons.

MEs carry in general a superposition of harmonics of some basic frequency determined by the length of ME. A natural expectation is that the frequency of classical field corresponds to the generalized de Broglie frequency of dark photon and is thus $\hbar/\hbar_s$ times lower than for ordinary photons. In completely analogous manner de Broglie wave length is scaled up by $k = \hbar_s/\hbar$. Classically the decay of dark photons to visible photons would mean that an oscillation with frequency f inside topological light ray transforms to an oscillation of frequency f/k such that the intensity of the oscillation is scaled up by a factor k. Furthermore, the ME in question could naturally decompose into $1 < N_{cr} \leq 137$ ordinary photons in the case that dark atoms are in question. Of course also MEs could decay to lower level MEs and this has an interpretation in terms of hierarchy of dark matters to be discussed next.

2.4.2 About the criterion for the transition increasing the value of Planck constant

An attractive assumption is that the transition to dark matter phase occurs when the interaction strength satisfies the criticality condition $Q_1Q_2\alpha \simeq 1$. A special case corresponds to self interaction with $Q_1 = Q_2$. This condition applies only to gauge interactions so that particles can be characterized by gauge charges. A more general characterization would be that transition occurs when perturbation theory ceases to converge. The criterion cannot be applied to phenomenological QFT description of strong force in terms of, say, pion exchange.

Some examples are in order to test this view.

1. Transition from perturbative phase in QCD to hadronic phase is the most obvious application. The identification of valence quarks and gluons as dark matter would predict for them QCD size ($k = 107$ space-time sheet) of about electron Compton length. This does not change the QCD cross sections in the lowest order perturbation theory but makes them excellent predictions. It also provides completely new view about how color force determines the nuclear strong force indeed manifesting itself as long ranged harmonic oscillator potential, the long range of which becomes manifest in the case of neutron halos of size of 2.5×10^{-14} m [60]. One can also understand tetraneutron in this framework. This criterion applies also in QCD plasma and explains the formation of liquid like color glass condensate detected in RHIC [34]. A possible interpretation for QCD size would be as a length of the cylindrical magnetic walls defining the magnetic body associated with u and d type valence quarks,

nucleons, and nuclei. There is no need to assume that conformal weights are complex in this phase.

2. QCD size of quark must be distinguished from the electromagnetic size of quark associated with $k = 113$ space-time sheets of u and d quarks and assignable to the height of the magnetic body and defining the length scale of join along boundaries contacts feeding quark charges to $k = 113$ space-time sheets.

3. In the case of atomic nuclei the criterion would naturally apply to the electromagnetic interaction energy of two nucleon clusters inside nucleus or to to self energy ($Q^2\alpha_{em} = 1$). Quite generally, the size of the electromagnetic $k = 113$ space-time sheet would increase by a $n_F = 2^k \prod_s F_s$, where F_s are different Fermat primes (the known ones being $3, 5, 17, 257, 2^{16} + 1$), in the transition to large $\hbar$ phase. Especially interesting values of n_F seem to be of form $n_F = 2^{k11}$ and possibly also $n_F = 2^{k11} \prod_s F_s$. Similar criterion would apply in the plasma phase. Note that many free energy anomalies involve the formation of cold plasma [G2].

   The criterion would give in the case of single nucleus and plasma $Z \geq 12$ if the charges are within single space-time sheet. This is consistent with cold fusion involving Palladium nuclei [61]. Since u and d quarks have $k = 113$, they both and thus both neutrons and protons could make a transition to large $\hbar$ phase. This is consistent with the selection rules of cold fusion since the production of ^3He involves a phase transition pnp$_d$ $\rightarrow$ pnp and the contraction of p_d to p is made un-probable by the Coulomb wall whereas the transition nnp$_d$ $\rightarrow$nnp producing tritium does not suffer from this restriction.

Strong and weak physics of nuclei would not be affected in the phase transition. Electromagnetic perturbative physics of nuclei would not be affected in the process in the lowest order in $\hbar$ (classical approximation) but the height of the Coulomb wall would be reduced by a factor $1/n_F$ by the increase in the electromagnetic size of the nucleus. Also Pd nuclei could make the transition and Pd nuclei could catalyze the transition in the case the deuterium nuclei.

2.5 Could one demonstrate the existence of large Planck constant photons using ordinary camera or even bare eyes?

If ordinary light sources generate also dark photons with same energy but with scaled up wavelength, this might have effects detectable with camera and even with bare eyes. In the following I consider in a rather light-hearted and speculative spirit two possible effects of this kind appearing in both visual perception and in photos. For crackpotters I want to make clear that I love to play with ideas to see whether they work or not, and that I am ready to accept some convincing mundane explanation of these effects and I would be happy to hear about this kind of explanations. I was not able to find any such explanation from Wikipedia using words like camera, digital camera, lense, aberrations [50].

2.5.1 Why light from an intense light source seems to decompose into rays?

If one also assumes that ordinary radiation fields decompose in TGD Universe into topological light rays ("massless extremals", MEs) even stronger predictions follow. If Planck constant equals to $\hbar = q \times \hbar_0$, $q = n_a/n_b$, MEs should possess Z_{n_a} as an exact discrete symmetry group acting as rotations along the direction of propagation for the induced gauge fields inside ME.

The structure of MEs should somewhat realize this symmetry and one possibility is that MEs has a wheel like structure decomposing into radial spokes with angular distance $\Delta\phi = 2\pi/n_a$ related by the symmetries in question. This brings strongly in mind phenomenon which everyone can observe anytime: the light from a bright source decomposes into radial rays as if one were seeing the profile of the light rays emitted in a plane orthogonal to the line connecting eye and the light source. The effect is especially strong if eyes are stirred. It would seem that focusing makes the effect stronger.

Could this apparent decomposition to light rays reflect directly the structure of dark MEs and could one deduce the value of n_a by just counting the number of rays in camera picture, where the phenomenon turned to be also visible? Note that the size of these wheel like MEs would be macroscopic and diffractive effects do not seem to be involved. The simplest assumption is that most of photons giving rise to the wheel like appearance are transformed to ordinary photons before their detection.

The discussions about this led to a little experimentation with camera at the summer cottage of my friend Samppa Pentikäinen, quite a magician in technical affairs. When I mentioned the decomposition of light from an intense light source to rays at the level of visual percept and wondered whether the same occurs also in camera, Samppa decided to take photos with a digital camera directed to Sun. The effect occurred also in this case and might correspond to decomposition to MEs with various values of n_a but with same quantization axis so that the effect is not smoothed out.

What was interesting was the presence of some stronger almost vertical "rays" located symmetrically near the vertical axis of the camera. In old-fashioned cameras the shutter mechanism determining the exposure time is based on the opening of the first shutter followed by closing a second shutter after the exposure time so that every point of sensor receives input for equally long time. The area of the region determining input is bounded by a vertical line. If macroscopic MEs are involved, the contribution of vertical rays is either nothing or all unlike that of other rays and this might somehow explain why their contribution is enhanced. The shutter mechanism is unnecessary in digital cameras since the time for the reset of sensors is what matters. Something in the geometry of the camera or in the reset mechanism must select vertical direction in a preferred position. For instance, the outer "aperture" of the camera had the geometry of a flattened square.

2.5.2 Anomalous diffraction of dark photons

Second prediction is the possibility of diffractive effects in length scales where they should not occur. A good example is the diffraction of light coming from a small aperture of radius d. The diffraction pattern is determined by the Bessel function

$$J_1(x) \ , \ x = kdsin(\theta) \ , \ k = 2\pi/\lambda .$$

There is a strong light spot in the center and light rings around whose radii increase in size as the distance of the screen from the aperture increases. Dark rings correspond to the zeros of $J_1(x)$ at $x = x_n$ and the following scaling law for the nodes holds true

$$sin(\theta_n) = x_n \frac{\lambda}{2\pi d} per.$$

For very small wavelengths the central spot is almost point-like and contains most light intensity.

If photons of visible light correspond to large Planck constant $\hbar = q \times \hbar_0$ transformed to ordinary photons in the detector (say camera film or eye), their wavelength is scaled by q, and one has

$$sin(\theta_n) \rightarrow q \times sin(\theta_n)$$

The size of the diffraction pattern for visible light is scaled up by q.

This effect might make it possible to detect dark photons with energies of visible photons and possibly present in the ordinary light.

1. What is needed is an intense light source and Sun is an excellent candidate in this respect. Dark photon beam is also needed and n dark photons with a given visible wavelength λ could result when dark photon with $\hbar = n \times q \times \hbar_0$ decays to n dark photons with same wavelength but smaller Planck constant $\hbar = q \times \hbar_0$. If this beam enters the camera or eye one has a beam of n dark photons which forms a diffraction pattern producing camera picture in the de-coherence to ordinary photons.

2. In the case of an aperture with a geometry of a circular hole, the first dark ring for ordinary visible photons would be at $sin(\theta) \simeq (\pi/36)\lambda/d$. For a distance of $r = 2$ cm between the sensor plane ("film") and effective circular hole this would mean radius of $R \simeq rsin(\theta) \simeq 1.7$ micrometers for micron wave length. The actual size of spots is of order $R \simeq 1$ mm so that the value of q would be around 1000: $q = 2^{10}$ and $q = 2^{11}$ belong to the favored values for q.

3. One can imagine also an alternative situation. If photons responsible for the spot arrive along single ME, the transversal thickness R of ME is smaller than the radius of hole, say of of order of wavelength, ME itself effectively defines the hole with radius R and the value of $sin(\theta_n)$ does not depend on the value of d for $d > R$. Even ordinary photons arriving along MEs of this kind could give rise to an anomalous diffraction pattern. Note that the transversal thickness of ME need not be fixed however. It however seems that MEs are now macroscopic.

4. A similar effect results as one looks at an intense light source: bright spots appear in the visual field as one closes the eyes. If there is some more mundane explanation (I do not doubt this!), it must apply in both cases and explain also why the spots have precisely defined color rather than being white.

5. The only mention about effects of diffractive aberration effects are colored rings around say disk like objects analogous to colors around shadow of say disk like object. The radii of these diffraction rings in this case scale like wavelengths and distance from the object.

6. Wikipedia contains an article from which one learns that the effect in question is known as lens flares [51]. The article states that flares typically manifest as several starbursts, circles, and rings across the picture and result in internal reflection and scattering from material inhomogenities in lens (such as multiple surfaces). The shape of the flares also depends on the shape of aperture. These features conform at least qualitatively with what one would expect from a diffraction if Planck constant is large enough for photons with energy of visible photon.

   The article [52] defines flares in more restrictive manner: lense flares result when *non-image* forming light enters the lens and subsequently hits the camera's film or digital sensor and produces typically polygonal shape with sides which depend on the shape of lense diaphgram. The identification as a flare applies also to the apparent decomposition to rays and this dependence indeed fits with the observations.

The experimentation of Samppa using digital camera demonstrated the appearance of colored spots in the pictures. If I have understood correctly, the sensors defining the pixels of the picture are in the focal plane and the diffraction for large Planck constant might explain the phenomenon. Since I did not have the idea about diffractive mechanism in mind, I did not check whether fainter colored rings might surround the bright spot.

1. In any case, the readily testable prediction is that zooming to bright light source by reducing the size of the aperture should increase the size and number of the colored spots. As a matter fact, experimentation demonstrated that focusing brought in large number of these spots but we did not check whether the size was increased.

2. Standard explanation predicts that the bright spots are present also with weaker illumination but with so weak intensity that they are not detected by eye. The positions of spots should also depend only on the illumination and camera. The explanation in terms of beams of large Planck constant photons predicts this if the flux of dark photons from any light source is constant.

2.6 Dark matter and exotic color and electro-weak interactions

The presence of classical electro-weak and color gauge fields in all length scales is an unavoidable prediction of TGD and the interpretation in terms of hierarchy of dark matters in some sense is also more or less unavoidable.

2.6.1 Does dark matter provide a correct interpretation of long ranged classical electro-weak gauge fields?

For two decades one of the basic interpretational challenges of TGD has been to understand how the un-avoidable presence of long range classical electro-weak gauge fields can be consistent with the small parity breaking effects in atomic and nuclear length scales. Also classical color gauge fields are predicted, and I have proposed that color qualia correspond to increments of color quantum numbers [K3]. The proposed model for screening cannot banish the unpleasant feeling that the screening cannot be complete enough to eliminate large parity breaking effects in atomic length scales so that one one must keep mind open for alternatives.

p-Adic length scale hypothesis suggests the possibility that both electro-weak gauge bosons and gluons can appear as effectively massless particles in several length scales and there indeed exists evidence that neutrinos appear in several scaled variants [23] (for TGD based model see [F3]).

This inspires the working hypothesis that long range classical electro-weak gauge and gluon fields are correlates for light or massless dark electro-weak gauge bosons and gluons.

1. In this kind of scenario ordinary quarks and leptons could be essentially identical with their standard counterparts with electro-weak charges screened in electro-weak length scale so that the problems related to the smallness of atomic parity breaking would be trivially resolved.

2. In condensed matter blobs of size larger than neutrino Compton length (about 5 μm if $k = 169$ determines the p-adic length scale of condensed matter neutrinos) the situation could be different. Also the presence of dark matter phases with sizes and neutrino Compton lengths corresponding to the length scales $L(k)$, $k = 151, 157, 163, 167$ in the range 10 nm-2.5 μm are suggested by the number theoretic considerations (these values of k correspond to so called Gaussian Mersennes [K2]). Only a fraction of the condensed matter consisting of regions of size $L(k)$ need to be in the dark phase.

3. Dark quarks and leptons would have masses essentially identical to their standard model counterparts. Only the electro-weak boson masses which are determined by a different mechanism than the dominating contribution to fermion masses [F2, F3] would be small or vanishing.

4. The large parity breaking effects in living matter would be due to the presence of dark nuclei and leptons. Later the idea that super-fluidity corresponds to Z^0 super-conductivity will be discussed: it might be that also super-fluid phase corresponds to dark neutron phase.

The basic prediction of TGD based model of dark matter as a phase with a large value of Planck constant is the scaling up of various quantal length and time scales. A simple quantitative model for condensed matter with large value of $\hbar$ predicts that $\hbar$ is by a factor $\sim 2^{11}$ determined by the ratio of CP_2 length to Planck length larger than in ordinary phase meaning that the size of dark neutrons would be of order atomic size. In this kind of situation single order parameter would characterize the behavior of dark neutrinos and neutrons and the proposed model could apply as such also in this case.

Dark photon many particle states behave like laser beams decaying to ordinary photons by de-coherence meaning a transformation of dark photons to ordinary ones. Also dark electro-weak bosons and gluons would be massless or have small masses determined by the p-adic length scale in question. The decay products of dark electro-weak gauge bosons would be ordinary electro-weak bosons decaying rapidly via virtual electro-weak gauge boson states to ordinary leptons. Topological light rays ("massless extremals") for which all classical gauge fields are massless are natural space-time correlates for the dark boson laser beams. Obviously this means that the basic difference between the chemistries of living and non-living matter would be the absence of electro-weak symmetry breaking in living matter (which does not mean that elementary fermions would be massless).

In super-canonical conformal weights are non-vanishing and can vary then Fermi statistics allows neutrinos to have same energy if their conformal weights are different so that a kind "fermionic Bose-Einstein condensate" would be in question. If both nuclear neutrons and neutrinos are in dark phase, it is possible to achieve a rather complete local cancellation of Z^0 charge density. The arguments of [C5] suggest that the original assumption that the net super-canonical conformal weight of states (conformal confinement) is real could be given up.

The model for neutrino screening was developed years before the ideas about the identification of the dark matter emerged. The generalization of the discussion to the case of dark matter option should be rather trivial and is left to the reader as well as generalization of the discussion of the effects of long range Z^0 force on bio-chemistry.

2.6.2 Criterion for the presence of exotic electro-weak bosons and gluons

Classical gauge fields directly are space-time correlates of quantum states. The gauge fields associated with massless extremals ("topological light rays") decompose to free part and a part having non-vanishing divergence giving rise to a light-like Abelian gauge current. Free part would correspond to Bose-Einstein condensates and current would define a coherent state of dark photons.

The dimension D of the CP_2 projection of the space-time sheet serves as a criterion for the presence of long ranged classical electro-weak and gluon fields. D also classifies the (possibly asymptotic) solutions of field equations [D1].

1. For $D = 2$ induced gauge fields are Abelian and induced Kähler form vanishes for vacuum extremals: in this case classical em and Z^0 fields are proportional to each other. The non-vanishing Kähler field implies that induced gluon fields are non-vanishing in general. This raises the question whether long ranged color fields and by quantum classical correspondence also long ranged QCD accompany non-vacuum extremals in all length scales. This makes one wonder whether color confinement is possible at all and whether scaled down variants of QCD appear in all length scales.

   The possibility to add constants to color Hamiltonians appearing in the expression of the classical color gauge fields allows to have vanishing color charges in the case of an arbitrary space-time sheet. The requirement that color quantum numbers of the generator vanish allows to add the constant only to the Hamiltonians of color hyper charge and isospin so that for $D = 2$ extremals color charges can be made vanishing. This might allow to understand how color confinement is consistent with long ranged induced Kähler field.

2. For $D \geq 3$ all classical long ranged electro-weak fields and non-Abelian color fields are present. This condition is satisfied when electric and magnetic fields are not orthogonal and

the instanton density $A \wedge J$ for induced Kähler form is non-vanishing. The rather strong conclusion is that in length scales in which exotic electro-weak bosons are not present, one has $D = 2$ and gauge fields are Abelian and correspond trivially to fixed points of renormalization group realized as a hydrodynamic flow at space-time sheets [C3].

Quantum classical correspondence suggests the existence of electro-weak gauge bosons with mass scale determined by the size of the space-time sheets carrying classical long range electro-weak fields. This would mean the existence of new kind of gauge bosons.

The obvious objection is that the existence of these gauge bosons would be reflected in the decay widths of intermediate gauge bosons. The remedy of the problem is based on the notion of space-time democracy suggested strongly by the fact that the interactions between space-time sheets possessing different p-adic topologies proceed with very slow rates simply because the number of common rational (algebraic) points of partonic 2-surfaces appearing in the vertex is small.

For light exotic electro-weak bosons also the corresponding leptons and quarks would possess a large weak space-time sheet but lack the ordinary weak partonic 2-surface so that there would be no direct coupling to electro-weak gauge bosons. These space-time sheets are dark in weak sense but need not have a large value of $\hbar$. This picture implies the notion of partial darkness since any space-time sheets with different ordinary of Gaussian primes are dark with respect to each other.

2.6.3 Do Gaussian Mersennes define a hierarchy of dark electro-weak physics?

Gaussian Mersennes are defined as Gaussian primes of form $g_n = (1+i)^n - 1$, where n must be prime. They have norm squared $g\overline{g} = 2^n - 1$. The list of the first Gaussian Mersennes corresponds to the following values of n.

2, 3, 5, 7, 11, 19, 29, 47, 73, 79, 113, 151, 157, 163, 167, 239, 241, 283, 353, 367, 379, 457, 997, 1367, 3041, 10141, 14699, 27529, 49207, 77291, 85237, 106693, 160423 and 203789.

The Gaussian primes $k = 113, 151, 157, 163, 167$ correspond to length scales which are of most obvious interest but in TGD framework one cannot exclude the twin prime $239, 241$ corresponds to length scales $L(k) \simeq 160$ km and 320 km. Also larger primes could be of relevant for bio-systems and consciousness. Also the secondary and higher length scales associated with $k < 113$ could be of importance and their are several length scales of this kind in the range of biologically interesting length scales. Physics and biology inspired considerations suggests that particular Gaussian primes correspond to a particular kind of exotic matter, possibly also to large $\hbar$ phase.

$k = 113$ corresponds to the electromagnetic length scale of u and d quarks and nuclear p-adic length scale. For dark matter these length scales are scaled up by a factor $\sim 2^{11}n$, where n is an integer. For $k = 113$ one obtains atomic length scale .8 A for $n = 1$. $k = 151, 153, 163, 167$ correspond to biologically important p-adic length scales varying in the range 10 nm-2.5 μm with the scaled up length scales varying in the range 2 μm- 5 mm.

On basis of biological considerations (large parity breaking in living matter) there is a temptation to assign to these length scales a scaled down copy of electro-weak physics and perhaps also of color physics. The mechanism giving rise to these states would be a phase transition transforming the ordinary $k = 89$ Mersenne of weak space-time sheets to a Gaussian Mersenne and thus increasing its size dramatically.

If given space-time sheet couples considerably only to space-time sheets characterized by same prime or Gaussian prime, the bosons of these physics do not couple directly to ordinary particles, and one avoids consistency problems due to the presence of new light particles (consider only the decay widths of intermediate gauge bosons [F5]) even in the case that the loss of asymptotic freedom is not assumed.

A question arises about the interpretation of structures of the predicted size. The strong interaction size of u and d quarks, hadrons, and nuclei is smaller than $L(k = 113) \simeq 2 \times 10^{-4}$ m for even heaviest nuclei if one accepts the formula $R \sim A^{1/3} \times 1.5 \times 10^{-15}$ m. A natural interpretation for this length scale would be as the size of the field body/magnetic body of system defined by its topologically quantized gauge fields/magnetic parts of gauge fields. The (possibly dark) p-adic length scale characterizes also the lengths of join along boundaries bonds feeding gauge fluxes from elementary particle to the space-time sheet in question. The delocalization due these join along boundaries bonds in p-adic length scale in question would determine the scale of the contribution to the mass squared of the system as predicted by p-adic thermodynamics.

2.7 Anti-matter and dark matter

The usual view about matter anti-matter asymmetry is that during early cosmology matter-antimatter asymmetry characterized by the relative density difference of order $r = 10^{-9}$ was somehow generated and that the observed matter corresponds to what remained in the annihilation of quarks and leptons to bosons. A possible mechanism inducing the CP asymmetry is based on the CP breaking phase of CKM matrix.

The TGD based view about energy [D3, D5] forces the conclusion that all conserved quantum numbers including the conserved inertial energy have vanishing densities in cosmological length scales. Therefore fermion numbers associated with matter and antimatter must compensate each other. Therefore the standard option is definitely excluded in TGD framework.

An early TGD based scenario explains matter antimatter asymmetry by assuming that antimatter is in vapor phase. This requires that matter and antimatter have slightly different topological evaporation rates with the relative difference of rates characterized by the parameter r. A more general scenario assumes that matter and antimatter reside at different space-time sheets. The reader can easily guess the next step. The strict non-observability of antimatter finds an elegant explanation if anti-matter is dark matter.

3 Dark variants of nuclear physics

The book metaphor for the extended imbedding space can be utilized as a guideline as one tries to imagine various exotic phases of matter. Atomic nuclei are assumed to be ordinary (in the sense of nuclear string model!) and only field bodies can be dark. They are analogous to n-sheeted Riemann surfaces. Nuclei can be visualized as residing at the "standard" pages of the book and dark color-/weak-/em- bonds are at different pages with different p-adic length scale or having different Planck constant $\hbar_{eff}$. This would give two hierarchies of nuclei with increasing size.

3.1 Constraints from the nuclear string model

In the case of exotic nuclei nuclear string model [F9] is a safe starting point. In this model nucleons are connected by color flux tubes having exotic light fermion and antifermion at their ends. Whether fermion is quark or colored excitation of lepton remains open question at this stage. The mass of the exotic fermion is much smaller than 1 MeV (p-adic temperature $T = 1/n < 1$). This model predicts large number of exotic states since color bonds, which can be regarded as colored pions, can have em charges (1,-1,0). In particular, neutral variant of deuterium is predicted and this leads to a model of cold fusion explaining its basic selection rules. The earlier model for cold fusion discussed in [F8], which served as a constraint in the earlier speculations, is not so simple than the model of [F9] .

What is important that the model requires that weak bosons for which Compton length is of order atomic size are involved. Weak bosons would behave as massless particles below the Compton and the rates for the exchanges of weak bosons would be high in the length scales considered. Weak bosons would correspond to scaled up variants of the ordinary weak bosons: scaling could be p-adic in which mass scale is reduced and weak interaction rates even above Compton length would be scaled up as $1/M_W^4$. The scaling could result also from the scaling of Planck constant in which case masses of weak bosons nor weak interaction rates in the lowest order would not be affected. If only dark scaling is involved, weak interactions would be still extremely weak above dark Compton length of weak bosons. Of course, both scalings can be imagined.

The scale of the color binding energy is $E_s = .2$ MeV for ordinary ${}^4He$ strings [D4]. $k = 151, 157, 163, 167$ define Gaussian Mersennes $G_k^{-}(1+i)^k - 1$ and excellent candidates for biologically important p-adic length scales. If M_{127} is scaled up to Gaussian Mersenne G_{167}, one obtains cell-nucleus sized (5 μm) exotic nuclei and the unit of color binding energy is still .2 eV. For p-adic length scale of order 100 μm (size of large neuron) the energy scale is still around thermal energy at room temperature.

In the case of dark color bonds it is not quite clear how the unit E_s of the color binding energy scales. If color Coulombic energy is in question, one expects $1/\hbar^2$ scaling. Rather remarkably, this scaling predicts that the unit for the energy of $A < 4$ color bond scales down to .5 eV which is the energy of hydrogen bond so that hydrogen bonds, and also other molecular bonds, might involve color bonds between proton and oxygen.

3.2 Constraints from the anomalous behavior of water

$H_{1.5}O$ behavior of water with respect to neutron and electron scattering is observed in attosecond time scale which corresponds to 3 Angstrom length scale, defining an excellent candidate for the size scale of exotic nuclei and Compton length of exotic weak interactions.

3.2.1 What happens to the invisible protons?

A possible explanation for the findings is that one fourth of protons forms neutral multi-proton states connected by possibly negatively charged color bonds of length differing sufficiently from the length of ordinary O-H bond. Although the protons are ordinary, neutron diffraction reflecting the crystal like order of water in atomic length scales would not see these poly-proton super-nuclei if they form separate closed strings.

1. For the ordinary nuclei the p-adic length scale associated with the color bonds between ${}^4He$ corresponds to M_{127}, and one can imagine exotic nuclear strings obtained by connecting two ordinary nuclei with color bonds. If second exotic nucleus is neutral (the model of cold fusion assumes that D nucleus is neutral) this could work since the Coulomb wall is absent. If the exotic nuclei have opposite em charges, the situation improves further. New super-dense phases of condensed matter would be predicted.

   If one fourth of hydrogen nuclei of water combine to form possibly neutral nuclear strings with average distance of nuclei of order $L(127)$, they are not visible in diffraction at atomic length scale because the natural length scale is shortened by a factor of order 32 but could be revealed in neutron diffraction at higher momentum exchanges. The transition between this kind of phase and ordinary nuclei would be rather dramatic event and the exchanges of exotic weak bosons with Compton lengths of order atomic size induce the formation of this kind of nuclei (this exchange is assumed in the model of cold fusion).

2. If dark color magnetic bonds are allowed, a natural distance between the building blocks of super-nuclei is given by the size scale of the color magnetic body. The size scales of dark color magnetic bodies associated with nuclear strings consisting of ${}^4He$, ${}^4He$ and $A \leq 3$ color magnetic bodies would be $L(127 + 22 = 149) = 5$ nm, $L(118 + 22 = 140) = 2.2$ Angstrom, and $L(116 + 22 = 138) = 1.1$ Angstrom. The first scale equals to the thickness of lipid layer of cell membrane which suggests a direct connection with biology. The latter two scales

correspond to molecular length scales and it is not clear why the protons of dark nuclear strings of this kind would not be observed in electron and neutron scattering. This would leave only nuclear strings formed from ^4He nuclei into consideration.

The crucial parameter is the the unit E_s of the color binding energy. Since this parameter should correspond to color Coulombic potential it could transform like the binding energy of hydrogen atom and therefore scale as $1/hbar^2$. This would mean that $E_s = 2.2$ MeV deduced from the deuteron binding energy would scale down to .5 eV for $n = 2^{11}$. This is the energy of hydrogen bond so that hydrogen bonds might have interpretation as color bonds between nuclei. Nuclear color bonds could serve as prerequisites for the formation of bond at level of valence electrons also in the case of other bonds.

For ^4He color bonds one would obtain $E_s = .05$ for so that the invisible protons could also belong to dark ^4He nuclear strings. The predicted $E_s = .05$ eV is very near to the energy associated with the membrane potential at the threshold for the generation of nerve pulse.

3. The third option is that color bonds have $n = 3 \times 2^{11}$ instead of $n = 2^{11}$. The color bond would be 9 times longer and probably also the distance between color bonded protons would be longer. In this case one would have $E_s = .056$ eV which is also near to the value of action potential.

The transition between the dark and ordinary nuclei would be favored by the minimization of Coulomb energy and energy differences would be small because of darkness. The transitions in which ordinary proton becomes dark and fuses to super-nuclear string or vice versa could be the basic control mechanism of bio-catalysis. Metabolic energy quantum .5 eV should relate to this transition.

Magic nuclei could have fractally scaled up variants in molecular length scale and tedrahedral and icosahedral water clusters could correspond to $A = 8$ and $A = 20$ magic nuclei with color bonds connecting nucleons belonging to different dark nuclei.

3.2.2 About the identification of the exotic weak physics?

The model of cold fusion requires exotic weak physics with the range of weak interaction of order atomic radius.

1. One can consider the possibility of $k = 113$ dark weak physics with $n = 2^{11}$. Weak Compton length for $k = 113$ dark weak bosons would be about 1.5 Angstrom. Above $L(135)$ weak bosons would have the mass scale $2^{-12}m_W \sim 25$ MeV and weak rates would be scaled up by 2^{48}. In [F9] it is proposed that isospin dependent strong force is nothing but a scaled variant of electro-weak force appearing as several fractally scaled up variants. Bohr radius would represent a critical transition length scale and exotic weak force could have dramatic implications for the behavior of the condensed matter in high pressures when exotic weak force would become visible.

2. Also exotic weak bosons corresponding to the ordinary value of Planck constant and to the atomic length scale $k = 137$ could be present. In this case the weak mass scale would be $2^{-24}m_W \sim 6$ eV and Compton length would be 3 Angstroms. New eV scale weak physics possibly relevant for molecular physics would be predicted. The transitions between nuclear strings and ordinary nuclei would involve nuclear energies so that this option is not favored as an explanation of $H_{1.5}O$ anomaly.

To sum up, it would seem that the variant of ordinary nuclear physics obtained by making color bonds and weak bonds dark is the most promising approach to the $H_{1.5}O$ anomaly and cold fusion. Exotic weak bosons with Compton wave length of atomic size and the most natural assumption is that they are dark $k = 113$ weak bosons. One variant of exotic atoms is as atoms for which electromagnetic interaction between ordinary nuclei and ordinary electrons is mediated along dark topological field quanta.

3.3 Exotic chemistries and electromagnetic nuclear darkness

The extremely hostile and highly un-intellectual attitude of skeptics stimulates fear in anyone possessing amygdala, and I am not an exception. Therefore it was a very pleasant surprise to receive an email telling about an article published in April 16, 2005 issue of New Scientist [44]. The article gives a popular summary about the work of the research group of Walter Knight with Na atom clusters [45] and of the research group of Welford Castleman with Al atom clusters [46].

The article tells that during last two decades a growing evidence for a new kind of chemistry have been emerging. Groups of atoms seem to be able to mimic the chemical behavior of single atom. For instance, clusters of 8, 20, 40, 58 or 92 sodium atoms mimic the behavior of noble gas atoms [45]. By using oxygen to strip away electrons one by one from clusters of Al atoms it is possible to make the cluster to mimic entire series of atoms [46]. For aluminium cluster-ions made of 13, 23 and 37 atoms plus an extra electron are chemically inert.

One can imagine two explanations for the findings.

1. The nuclei are dark in the sense that the sizes of nuclear space-time sheets are scaled up implying the smoothing out of the nuclear charge.

2. Only electrons are dark in the sense of having scaled up Compton lengths so that the size of multi-electron bound states is not smaller than electron Compton length and electrons "see" multi-nuclear charge distribution.

If darkness and Compton length is assigned with the em field body, it becomes a property of interaction, and it seems impossible to distinguish between options 1) and 2).

3.3.1 What one means with dark nuclei and electrons?

Can the idea about dark nuclei and electrons be consistent with the minimalist picture in which only field bodies are dark? Doesn't the darkness of nucleus or electron mean that also multi-electron states with n electrons are possible?

The proper re-interpretation of the notion Compton length would allow a consistency with the minimalist scenario. If the p-adic prime labelling the particle actually labels its electromagnetic body as p-adic mass calculations for quark masses encourage to believe, Compton length corresponds to the size scale of the electromagnetic field body and the models discussed below would be consistent with the minimal scenario. Electrons indeed "see" the external charge distribution by their electromagnetic field body and field body also carries this distribution since CP_2 extremals do not carry it. One could also defend this interpretation by saying that electrons is operationally only what can be observed about it through various interactions and therefore Compton length (various Compton length like parameters) must be assigned with its field body (bodies).

Also maximal quantum criticality implies that darkness is restricted to field bodies but does not exclude the possibility that elementary particle like structures can possess non-minimal quantum criticality and thus possess multi-sheeted character.

3.3.2 Option I: nuclei are electromagnetically dark

The general vision about nuclear dark matter suggests that the system consists of super-nuclei analogous to ordinary nuclei such that electrons are ordinary and do not screen the Coulomb potentials of atomic nuclei.

The simplest possibility is that the electromagnetic field bodies of nuclei or quarks become dark implying delocalization of nuclear charge. The valence electrons would form a kind of mini-conductor with electrons delocalized in the volume of the cluster. The electronic analog of the nuclear shell model predicts that full electron shells define stable configurations analogous to magic nuclei. The model explains the numbers of atoms in chemically inert Al and Ca clusters and generalizes the notion of valence to the level of cluster so that the cluster would behave like single super-atom.

The electromagnetic $k = 113$ space-time sheets (em field bodies) of quarks could have scaled up size $nL(113)/v_0 = n2^{11} \times 2 \times 10^{-14}$ m, $n = 1, 2, 3$. One would have atomic size 1 Angstrom for $n = 1$. A suggestive interpretation is that the electric charge of nuclei or valence quarks assignable to their field bodies is delocalized quantum mechanically to atomic length scale. Electrons would in a good approximation experience quantum mechanically the nuclear charges as a constant background, jellium, whose effect is indeed modellable using harmonic oscillator potential.

One can test the proposed criterion for the phase transition to darkness. The unscreened electromagnetic interaction energy between a block of partially ionized nuclei with a net em charge Z with Z electrons would define the relevant parameter as $r \equiv Z^2\alpha$. For the total charge $Z \geq 12$ the condition $r \geq 1$ is satisfied. For a full shell with 8 electrons this condition is not satisfied.

3.3.3 Option II: Electrons are electro-magnetically dark

Since the energy spectrum of harmonic oscillator potential is invariant under the scaling of $\hbar$ accompanied by the opposite scaling of the oscillator frequency ω, one must consider also the em bodies of electrons are in large $\hbar$ phase (one can of course ask whether they could be observed in this phase!). The rule would be that the size of the bound states is larger than the scaled up electron Compton length.

The Compton wavelength of electrons would be scaled up by a factor $n2^{11}$, $n = 1, 3, 5$, where n is product of different Fermat primes, and correspond to $\sim n \times 5$ nm. The atomic cluster of this size would contain roughly $n \times 10^4(a_0/a)^3$ atoms where a is atomic volume and $a_0 = 1$ Angstrom is the natural unit.

The shell model of nucleus is in TGD framework a phenomenological description justified by nuclear string model with string tension responsible for the oscillator potential. This leads to ask whether the electrons of jellium actually form analogs of nuclear strings with electrons connected by color bonds.

4 Water and new physics

In this section the previous ideas are applied in an attempt to understand the very special properties of water.

4.1 The 41 anomalies of water

The following list of 41 anomalies of water taken from [35] should convince the reader about the very special nature of water. The detailed descriptions of the anomalies can be found in [35]. As a matter fact, the number of anomalies has now grown to 63.

1. Water has unusually high melting point.
2. Water has unusually high boiling point.
3. Water has unusually high critical point.
4. Water has unusually high surface tension and can bounce.
5. Water has unusually high viscosity.
6. Water has unusually high heat of vaporization.

7. Water shrinks on melting.
8. Water has a high density that increases on heating (up to 3.984°C).
9. The number of nearest neighbors increases on melting.
10. The number of nearest neighbors increases with temperature.
11. Pressure reduces its melting point (13.35 MPa gives a melting point of -1°C)
12. Pressure reduces the temperature of maximum density.
13. D_2O and T_2O differ from H_2O in their physical properties much more than might be expected from their increased mass; e.g. they have increasing temperatures of maximum density (11.185°C and 13.4°C respectively).
14. Water shows an unusually large viscosity increase but diffusion decrease as the temperature is lowered.
15. Water's viscosity decreases with pressure (at temperatures below 33°C).
16. Water has unusually low compressibility.
17. The compressibility drops as temperature increases down to a minimum at about 46.5°C. Below this temperature, water is easier to compress as the temperature is lowered.
18. Water has a low coefficient of expansion (thermal expansivity).
19. Water's thermal expansivity reduces increasingly (becoming negative) at low temperatures.
20. The speed of sound increases with temperature (up to a maximum at 73°C).
21. Water has over twice the specific heat capacity of ice or steam.
22. The specific heat capacity (C_P and C_V) is unusually high.
23. Specific heat capacity; C_P has a minimum.
24. NMR spin-lattice relaxation time is very small at low temperatures.
25. Solutes have varying effects on properties such as density and viscosity.
26. None of its solutions even approach thermodynamic ideality; even D_2O in H_2O is not ideal.
27. X-ray diffraction shows an unusually detailed structure.
28. Supercooled water has two phases and a second critical point at about -91°C.
29. Liquid water may be supercooled, in tiny droplets, down to about -70°C. It may also be produced from glassy amorphous ice between -123°C and - 149°C and may coexist with cubic ice up to -63°C.
30. Solid water exists in a wider variety of stable (and metastable) crystal and amorphous structures than other materials.
31. Hot water may freeze faster than cold water; the Mpemba effect.
32. The refractive index of water has a maximum value at just below 0°C.
33. The solubilities of non-polar gases in water decrease with temperature to a minimum and then rise.
34. At low temperatures, the self-diffusion of water increases as the density and pressure increase.
35. The thermal conductivity of water is high and rises to a maximum at about 130°C.
36. Proton and hydroxide ion mobilities are anomalously fast in an electric field.
37. The heat of fusion of water with temperature exhibits a maximum at -17°C.
38. The dielectric constant is high and behaves anomalously with temperature.
39. Under high pressure water molecules move further away from each other with increasing pressure.
40. The electrical conductivity of water rises to a maximum at about 230°C and then falls.
41. Warm water vibrates longer than cold water.

4.2 The model

Networks of directed hydrogen bonds $H - O - H \cdots OH_2$ with positively charged H acting as a binding unit between negatively charged O (donor) and OH_2 (acceptor) bonds explaining clustering of water molecules can be used to explain qualitatively many of the anomalies at least qualitatively [35].

The anomaly giving evidence for anomalous nuclear physics is that the physical properties D_2O and T_2O differ much more from H_2O than one might expect on basis of increased masses of water molecules. This suggests that dark protons of various sizes are responsible for the anomalies. That heavy water in large concentrations acts as a poison is consistent with the view that the macroscopic quantum phase of dark protons is responsible for the special biological role of water.

What proton darkness could mean? One fourth of protons of water are not seen in neither electron nor neutron scattering in atto-second time scale which translates n 3 Angstrom wavelength scale suggesting that in both cases diffraction scattering is in question. Both nuclear strong interactions and magnetic scattering contribute to the diffraction which is sensitive to the intra-atomic distances. The minimal conclusion is that the protons form a separate phase with inter-proton distance sufficiently different from that between water molecules and are therefore not seen in neutron and electron diffraction in the atto-second time scale at which protons of water molecule are visible. The stronger conclusion is that they are dark with respect to nuclear strong interactions.

The previous considerations inspired by the model of nuclei as nuclear strings suggests possible explanations.

1. Hydrogen atoms form analogs of nuclear strings connected by color bonds.

2. Nuclear protons form super-nuclei connected by dark color bonds or belong to such super-nuclei (possibly consisting of ^4He nuclei). If color bonds are negatively charged, closed nuclear strings of this kind are neutral and not visible in electron scattering: this assumption is however un-necessarily strong for invisibility in diffractive scattering in atto-second time scale.

4.2.1 Model for super-nuclei formed from dark protons

Dark protons could form super nuclei with nucleons connected by dark color bonds with $\hbar = k2^{11}\hbar_0$. The large distance between protons would eliminate isospin dependent strong force so that multi-proton states are indeed possible. The interpretation would be that nuclear size scale is zoomed up to $k2^{11}L(113) = kL(135) \sim .49k$ Angstrom, where n is Fermat integer: $k = 1, 3, 5$ are the smallest candidates. Dark color bonds could also connect different nuclei.

The predictions of the model for bond energy depend on the transformation properties of E_s under the scaling of $\hbar$. The interpretation of E_s as color Coulombic potential energy α_s/r suggests that E_s behaves under scaling like the binding energy of hydrogen atom ($1/\hbar^2$ scaling).

1. For $k = 1$ E_s would be about .5 eV and same as the energy of hydrogen bond. This energy is same as the universal metabolic energy quantum so that the basic metabolic processes might involve transitions dark-ordinary transition for protons. This would however suggest that the length of color bond is same as that of hydrogen bond so that the protons in question would not be invisible in diffraction in atto-second time scale. The interpretation of color bonds between atoms as hydrogen bonds is much more attractive.

2. For $k = 3$ one would have $E_s \rightarrow E_s/k^2 = .056$ eV which is the nominal value for the energy associated with the cell membrane potential at the threshold for nerve pulse generation and just above the thermal energy at room temperature. There is a temptation to assign the invisible protons suggested by the $H_{1.5}O$ formula [36] with $k = 3$ hydrogen bonds. The length of hydrogen bond is 1.6-2 Angstrom. If hydrogen bond length scales as E_s as the harmonic oscillator picture suggests, the distance would scale as k^2 and would be 9 times longer for $k = 3$ bond. This would explain the invisibility of corresponding hydrogen atoms in electron and neutron diffraction.

4.2.2 Hydrogen bonds as color bonds between nuclei?

The original hypothesis was that there are two kinds of hydrogen bonds: dark and "ordinary". The finding that the energy of dark nuclear color bond with $n = 2^{11}$ equals to the energy of typical hydrogen bond suggests that all hydrogen bonds are associated with color bonds between nuclei. Color bond would bind the proton to electronegative nucleus and this would lead to to the formation of hydrogen bond at the level of valence electrons as hydrogen donates its electron to the electronegative atom. The electronic contribution would explain the variation of the bond energy.

If hydrogen bonds connect H-atom to O-atom to acceptor nucleus, if E_s for p-O bond is same as for p-n color bond, and if color bonds are dark with $n = k2^{11}$, where k is Fermat integer, the bond energy is $E_s = 2.2MeV/n^2$. For $k = 1$ single bond is predicted to have bond energy $E_s = .5$ eV whereas the bond energy for n-bond structure energy would be n^2 times larger. The alternative hypothesis would be that hydrogen bonds are dark color bonds between atoms having $k = 118$ and $n = 2^{11}$.

Nuclear color bonds would serve as a prerequisite for the formation of electronic parts of hydrogen bonds and could be associated also with other molecular bonds so that dark nuclear physics might be essential part of molecular physics. Dark color bonds could be also charged which brings in additional exotic effects. The long range order of hydrogen bonded liquids could due to the ordinary hydrogen bonds. An interesting question is whether nuclear color bonds could be responsible for the long range order of all liquids. If so dark nuclear physics would be also crucial for the understanding of the condensed matter.

In the case of water the presence of $k = 3$ bonds between dark protons would bring in additional long range order in length scale of order 10 Angstrom characteristic for DNA transversal scale: also hydrogen bonds play a crucial role in DNA double strand. Two kinds of bond networks could allow to understand why water is so different from other molecular liquids containing also hydrogen atoms and the long range order of water molecule clusters would reflect basically the long range order of two kinds of dark nuclei.

4.2.3 Two kinds of hydrogen bonds

There is experimental evidence for two different hydrogen bonds but, contrary to the original belief, this does not relate to $H_{1.5}O$ anomaly. Li and Ross represent experimental evidence for two kinds of hydrogen bonds in ice in an article published in Nature 1993 [79], and there is a popular article "Wacky Water" in New Scientist about this finding [78]. The ratio of the force constants associated with the bonds is 1:2 which suggests that binding energies scale as 2:1. This finding excludes the possibility that all hydrogen bonds are ordinary for ice. The interpretation would that these bonds correspond to two different p-adic length scales differing by scale factor 2. $A \leq 4$ nucleons indeed correspond to p-adic length scales $L(k_{eff} = 116)$ and $L(k_{eff} = 118)$. Obviously these bonds cannot be identified as the two variants of color bond discussed above. A possible interpretation for tedrahedral and icosahedral water clusters would be as magic super-nuclei and the prediction would be that binding energy behaves as n^2E_s rather than being just the sum of the binding energies of hydrogen bonds (nE_s).

The possibility to divide the bonds to two kinds of bonds in an arbitrary manner brings in a large ground state degeneracy given by $D = 16!/(8!)^2$ unless additional symmetries are assumed and give for the system spin glass like character and explain large number of different amorphous phases for ice [35]. This degeneracy would also make possible information storage and provide water with memory.

It is interesting to compare this model with the model for hexagonal ice which assumes four hydrogen bonds per water molecule: for two of them the molecule acts as a donor and for two of them as an acceptor. Each water molecule in the vertices of a tedrahedron containing 14 hydrogen atoms has a hydrogen bond to a water molecule in the interior, each of which have 3 hydrogen bonds to molecules at the middle points of the edges of the tedrahedron. This makes 16 hydrogen bonds altogether. If all of them are of first type with bonding energy $E_s = .5$ eV and if the bond network is connected one would obtain total bond energy equal to $n^2E_s = 258 \times .5$ eV rather than only $nE_s = 16 \times .5$ eV. Bonds of second type would have no role in the model.

4.2.4 Tedrahedral and icosahedral clusters of water molecules and dark color bonds

Water molecules form both tedrahedral and icosahedral clusters. ^4He corresponds to tedrahedral symmetry so that tedrahedral cluster could be the condensed matter counterpart of ^4He. It the nuclear string model nuclear strings consist of maximum number of ^4He nuclei themselves closed strings in shorter length scale.

The p-adic length scales associated with ^4He nuclei and nuclear string are $k = 116$ and $k = 127$ The color bond between ^4He units has $E_s = .2$ MeV and $n = 2^{11}$ would give by scaling $E_s = .05$ eV which is the already familiar energy associated with cell membrane potential at the threshold for nerve pulse generation. This energy is in a good approximation associated also with $n = 3 \times 2^{11}$ color bonds so that the invisible hydrogen bonds might closely relate to the formation of icosahedral clusters. The binding energy associated with a string formed by n tedrahedral clusters would be n^2E_s. This observation raises the question whether the neural firing is accompanied by the re-organization of strings formed by the tedrahedral clusters and possibly responsible for a representation of information and water memory.

The icosahedral model [35] for water clusters assumes that 20 tedrahedral clusters, each of them containing 14 molecules, combine to form icosahedral clusters containing 280 water molecules. Concerning the explanation of anomalies, the key observation is that icosahedral clusters have a smaller volume per water molecule than tedrahedral clusters but cannot form a lattice structure. Note that the number 20 for the dark magic dark nuclei forming the icosahedron is also a magic number.

4.2.5 Tedrahedral and icosahedral clusters and dark electrons

An additional dark insight to tedrahedral and icosahedral structures is based on the observation that dark matter phases correspond to large values of n_a/n_b and there large value of M^4 Planck constant. This means $N(G_a)$-fold covering of CP_2 with the order of maximal cyclic subgroup of G_a being n_a. For tedrahedron and dodecahedron one has $n_a = 3$ and $n_a = 5$ respectively so that the increase of Planck constant would be relatively small and would correspond to Fermat polygon in both cases. These two groups are the only subgroups of $SO(3)$ which correspond to genuinely 3-dimensional symmetries. Of course, $n_a = 3$ and $n_a = 5$ have nothing to do with $n_a = 2^{11}$ but it is quite possible that also these dark matter levels are involved and could be assigned with dark electrons rather than dark color bonds between nuclei.

Synaptic contacts contain clathrin molecules which are truncated icosahedrons and form lattice structures and are speculated to be involved with quantum computation like activities possibly performed by microtubules. Many viruses have the shape of icosahedron. One can ask whether these structures could be formed around templates formed by dark matter corresponding to 120-fold covering of CP_2 points by M^4 points and having $\hbar(CP_2) = 5\hbar_0$ perhaps corresponding color confined light dark quarks. Of course, a similar covering of M^4 points by CP_2 could be involved.

It should be noticed that single nucleotide in DNA double strands corresponds to a twist of $2\pi/10$ per single DNA triplet so that 10 DNA strands corresponding to length $L(151) = 10$ nm (cell membrane thickness) correspond to $3 \times 2\pi$ twist. This could be perhaps interpreted as evidence for group C_{10} perhaps making possible quantum computation at the level of DNA.

4.3 Comments on 41 anomalies

Some clarifying general comments about the anomalies are in order. Quite generally, it seems that it is the presence of new degrees of freedom, the presence of icosahedral clusters, and macroscopic quantum coherence of dark matter, which are responsible for the peculiar properties of water.

1. Anomalies relating to the presence of icosahedral clusters

Icosahedral water clusters have a better packing ratio than tedrahedral lattice and thus correspond to a larger density. They also minimize energy but cannot cannot form a lattice [35].

1. This explains the unusually high melting point, boiling point, critical point, surface tension, viscosity, heat of vaporization, shrinking on melting, high density increasing on heating, increase of the number of nearest neighbors in melting and with temperature. It is also possible to understand why X-ray diffraction shows an unusually detailed structure.

   The presence of icosahedral clusters allows to understand why liquid water can be super-cooled, and why the distances of water molecules increase under high pressure. The spin glass degeneracy implied by dark and ordinary hydrogen bonds could explain why ice has many glassy amorphous phases. The two phases of super-cooled water could correspond to the binary degree of freedom brought in by two different hydrogen bonds. For the first phase both hydrogen atoms of a given water molecule would be either dark or ordinary. For the second phase the first hydrogen atom would be dark and second one ordinary.

   Since icosahedral clusters have lower energy than a piece of ice of same size, they tend to super-cool and this slows down the transition to the solid phase. The reason why hot water cools faster would be that the number of icosahedral clusters is smaller: if cooling is carried with a sufficient efficiency icosahedral clusters do not form.

2. Pressure can be visualized as a particle bombardment of water clusters tending to reduce their volume. The collisions with particles can induce local transitions of hexagonal lattice to icosahedral structures with a smaller specific volume and energy and induce local melting. This would explain the low compressibility of water and why pressure reduces melting point and the temperature of maximum density and viscosity.

3. The increase of temperature is expected to reduce the number of icosahedral clusters so that the effect of pressure on these clusters is not so large. This explains the increase of compressibility with temperature below 46.5°C. The fact that the collapse of icosahedral clusters opposes the usual thermal expansion is consistent with the low thermal expansivity as well as the change of sign of expansivity near melting point. Since the square of sound velocity is inversely proportional to compressibility and density, also the increase of speed of sound with temperature can be understood.

2. The presence of dark degrees of freedom and spin glass degeneracy

The presence of dark degrees of freedom and the degeneracy of dark nucleus ground states could explain the high specific heat capacity of water. The reduction of dark matter degrees of freedom for ice and steam would explain why water has over twice the specific heat capacity of ice or steam. The possibility to relax by dissipating energy to the dark matter degrees of freedom would explain the short spin-lattice relaxation time. The fact that cold water has more degrees of freedom explains why warm water vibrates longer than cold water.

Also the high thermal and electric conductivity of water could be understood. The so called Grotthuss mechanism [35, 29] explaining OH_- and H_+ mobilities (related closely to conductivities) is based on hopping of electron of OH_- and H_+ in the network formed by hydrogen bonds and generalizes to the recent case. The reduction of conductivity with temperature would be due to the storage of the transferred energy/capture of charge carriers to the water molecule clusters.

3. Macroscopic quantum coherence

The high value of dielectric constant could derive from the fact that dark nuclei and super-nuclei are quantum coherent in a rather long length scale. For curl free electric fields potential difference must be same along space-time sheets of matter and dark matter. The synchronous quantum coherent collective motion of dark protons (and possible dark electrons) in an oscillating external electric field generates dark photon laser beams (it is not clear yet whether these dark laser beams are actually ordinary laser beams) de-cohering to ordinary photons and yield a large dynamical polarization. As the temperature is lowered the effect becomes stronger.

4.4 Burning salt water by radio-waves and large Planck constant

This morning (Tuesday, 14 August 2007) my friend Samuli Penttinen send an email telling about strange discovery [98] by engineer John Kanzius: salt water in the test tube radiated by radiowaves at harmonics of a frequency f=13.56 MHz burns. Temperatures about 1500 K, which correspond to .15 eV energy have been reported. You can radiate also hand but nothing happens. The original discovery of Kanzius was the finding that radio waves could be used to cure cancer by destroying the cancer cells. The proposal is that this effect might provide new energy source by liberating chemical energy in an exceptionally effective manner. The power is about 200 W so that the power used could explain the effect if it is absorbed in resonance like manner by salt water.

The energies of photons involved are very small, multiples of 5.6×10^{-8} eV and their effect should be very small since it is difficult to imagine what resonant molecular transition could cause the effect. This leads to the question whether the radio wave beam could contain a considerable fraction of dark photons for which Planck constant is larger so that the energy of photons is much larger. The underlying mechanism would be phase transition of dark photons with large Planck constant to ordinary photons with shorter wavelength coupling resonantly to some molecular degrees of freedom and inducing the heating. Microwave oven of course comes in mind immediately.

1. The fact that the effects occur at harmonics of the fundamental frequency suggests that rotational states of molecules are in question as in microwave heating. Since the presence of salt seems to be essential, the first candidate for the molecule in question is NaCl but also HCl can be considered and also water molecules. NaCl makes sense if NaCl and Na^+ and Cl^- are in equilibrium. The formula for the rotational energies [48] is

$$E(l) = E_0 \times (l(l+1) \ \ , \ \ E_0 = \hbar_0^2/2\mu R^2 \ \ , \ \ \mu = m_1 m_2/(m_1+m_2) \ \ .$$

   Here R is molecular radius which by definition is deduced from the rotational energy spectrum. The energy inducing the transition $l \to l+1$ is $\Delta E(l) = 2E_0 \times (l+1)$.

2. By going to Wikipedia [49], one can find molecular radii of hetero-nuclear molecules such as $NaCl$ and homonuclear di-atomic molecules such as H_2. Using $E_0(H_2) = 8.0\times 10^{-3}$ eV one obtains by scaling

$$E_0(NaCl) = (\mu(H_2/\mu(NaCl)) \times (R(H_2)/R(NaCl)^2 \ \ .$$

   The atomic weights are $A(H) = 1, A(Na) = 23, A(Cl) = 35$.

3. A little calculation gives $f(NaCl) = 2E_0/h = 14.08$ GHz. The ratio to the radio wave frequency is $f(NaCl)/f = 1.0386\times 10^3$ to be compared with the $\hbar/\hbar_0 = 2^{10} = 1.024\times 10^3$. The discrepancy is 1 per cent.

Thus dark radio wave photons could induce a rotational microwave heating of the sample and the effect could be seen as an additional dramatic support for the hierarchy of Planck constants.

4. One can consider also the possibility that energy is feeded to the rotational degrees of freedom of water molecules as in microwave oven and salt has some other function. Both mechanisms could be involved of course. The microwave frequency used in microwave ovens is 2.45 GHz giving for the Planck constant the estimate 180.67 equal to 180 with error of .4 per cent. The values of Planck constants for $(\hat{M}^4/G_a) \times \hat{CP}_2 \hat{\times} G_b$ option (factor space of M^4 and covering space of CP_2 maximizing Planck constant for given G_a and G_b) are given by $\hbar/\hbar_0 = n_a n_b$. $n_a n_b = 4 \times 9 \times 5 = 180$ can result from the number theoretically simple values of quantum phases $exp(i2\pi/n_i)$ corresponding to polygons constructible using only ruler and compass. For instance, one could have $n_a = 2 \times 3$ and $n_b = 2 \times 3 \times 5$. This option gives a slightly better agreement than NaCl option.

There are several questions to be answered.

1. Does this effect occur also for solutions of other molecules and other solutes than water? This can be tested since the rotational spectra are readily calculable from data which can be found at net.

2. Are the radio wave photons dark or does water - which is very special kind of liquid - induce the transformation of ordinary radio wave photons to dark photons by fusing 2^{10} radio wave massless extremals (MEs) to single ME. Does this transformation occur for all frequencies? This kind of transformation might play a key role in transforming ordinary EEG photons to dark photons and partially explain the special role of water in living systems.

3. Why the radiation does not induce spontaneous combustion of living matter which contains salt. And why cancer cells seem to burn: is salt concentration higher inside them? As a matter fact, there are reports about [99]. One might hope that there is a mechanism inhibiting this since otherwise military would be soon developing new horror weapons unless it is doing this already now. Is it that most of salt is ionized to Na^+ and Cl^- ions so that spontaneous combustion can be avoided? And how this relates to the sensation of spontaneous burning [100] - a very painful sensation that some part of body is burning?

4. Is the energy heating solely due to rotational excitations? It might be that also a "dropping" of ions to larger space-time sheets is induced by the process and liberates zero point kinetic energy. The dropping of proton from k=137 (k=139) atomic space-time sheet liberates about .5 eV (0.125 eV). The measured temperature corresponds to the energy .15 eV. This dropping is an essential element of remote metabolism and provides universal metabolic energy quanta. It is also involved with TGD based models of "free energy" phenomena. No perpetuum mobile is predicted since there must be a mechanism driving the dropped ions back to the original space-time sheets.

Recall that one of the empirical motivations for the hierarchy of Planck constants came from the observed quantum like effects of ELF em fields at EEG frequencies on vertebrate brain and also from the correlation of EEG with brain function and contents of consciousness difficult to understand since the energies of EEG photons are ridiculously small and should be masked by thermal noise.

In TGD based model of EEG (actually fractal hierarchy of EEGs) the values $\hbar/\hbar_0 = 2^{k11}$, $k = 1, 2, 3, ...$, of Planck constant are in a preferred role. More generally, powers of two of a given value of Planck constant are preferred, which is also in accordance with p-adic length scale hypothesis.

5 Connection with mono-atomic elements, cold fusion, and sonofusion?

Anomalies are treasures for a theoretician and during years I have been using quite a bundle of reported anomalies challenging the standard physics as a test bed for the TGD vision about physics. The so called mono-atomic elements, cold fusion, and sonofusion represent examples of this kind of anomalies not taken seriously by most standard physicists. In the following the possibility that dark matter as large $\hbar$ phase could allow to understand these anomalies.

Of course, I hear the angry voice of the skeptic reader blaming me for a complete lack of source criticism and the skeptic reader is right. I however want to tell him that I am not a soldier in troops of either skeptics or new-agers. My attitude is "let us for a moment assume that these findings are real..." and look for the consequences in this particular theoretical framework.

5.1 Mono-atomic elements as dark matter and high T_c super-conductors?

The ideas related to many-sheeted space-time began to develop for a decade ago. The stimulation came from a contact by Barry Carter who told me about so called mono-atomic elements, typically transition metals (precious metals), including Gold. According to the reports these elements, which are also called ORMEs ("orbitally rearranged monoatomic elements") or ORMUS, have following properties.

1. ORMEs were discovered and patented by David Hudson [85] are peculiar elements belonging to platinum group (platinum, palladium, rhodium, iridium, ruthenium and osmium) and to transition elements (gold, silver, copper, cobalt and nickel).

2. Instead of behaving as metals with valence bonds, ORMEs have ceramic like behavior. Their density is claimed to be much lower than the density of the metallic form.

3. They are chemically inert and poor conductors of heat and electricity. The chemical inertness of these elements have made their chemical identification very difficult.

4. One signature is the infra red line with energy of order .05 eV. There is no text book explanation for this behavior. Hudson also reports that these elements became visible in emission spectroscopy in which elements are posed in strong electric field after time which was 6 times longer than usually.

The pioneering observations of David Hudson [85] - if taken seriously - suggest an interpretation as an exotic super-conductor at room temperature having extremely low critical magnetic fields of order of magnetic field of Earth, which of course is in conflict with the standard wisdom about super-conductivity. After a decade and with an impulse coming from a different contact related to ORMEs, I decided to take a fresh look on Hudson's description for how he discovered ORMEs [85] with dark matter in my mind. From experience I can tell that the model to be proposed is probably not the final one but it is certainly the simplest one.

There are of course endless variety of models one can imagine and one must somehow constrain the choices. The key constraints used are following.

1. Only valence electrons determining the chemical properties appear in dark state and the model must be consistent with the general model of the enhanced conductivity of DNA assumed to be caused by large $\hbar$ valence electrons with $r = \hbar/\hbar_0 = n$, $n = 5, 6$ assignable with aromatic rings. $r = 6$ for valence electrons would explain the report of Hudson about anomalous emission spectroscopy.

2. This model cannot explain all data. If ORMEs are assumed to represent very simple form of living matter also the presence electrons having $\hbar/\hbar_0 = 2^{k11}$, $k = 1$, can be considered and would be associated with high T_c super-conductors whose model predicts structures with thickness of cell membrane. This would explain the claims about very low critical magnetic fields destroying the claimed superconductivity.

Below I reproduce Hudson's own description here in a somewhat shortened form and emphasize that must not forget professional skepticism concerning the claimed findings.

5.1.1 Basic findings of Hudson

Hudson was recovering gold and silver from old mining sources. Hudson had learned that something strange was going on with his samples. In molten lead the gold and silver recovered but when "I held the lead down, I had nothing". Hudson tells that mining community refers to this as "ghost-gold", a non-assayable, non-identifiable form of gold.

Then Hudson decided to study the strange samples using emission spectroscopy. The sample is put between carbon electrodes and arc between them ionizes elements in the sample so that they radiate at specific frequencies serving as their signatures. The analysis lasts 10-15 seconds since for longer times lower electrode is burned away. The sample was identified as Iron, Silicon, and Aluminum. Hudson spent years to eliminate Fe, Si, and Al. Also other methods such as Cummings Microscopy, Diffraction Microscopy, and Fluorescent Microscopy were applied and the final conclusion was that there was nothing left in the sample in spectroscopic sense.

After this Hudson returned to emission spectroscopy but lengthened the time of exposure to electric field by surrounding the lower Carbon electrode with Argon gas so that it could not burn. This allowed to reach exposure times up to 300 s. The sample was silent up to 90 s after which emission lines of Palladium (Pd) appeared; after 110 seconds Platinum (Pt); at 130 seconds Ruthenium (Ru); at about 140-150 seconds Rhodium; at 190 seconds Iridium; and at 220 seconds Osmium appeared. This is known as fractional vaporization.

Hudson reports the boiling temperatures for the metals in the sample having in mind the idea that the emission begins when the temperature of the sample reaches boiling temperature inspired by the observation that elements become visible in the order which is same as that for boiling temperatures.

The boiling temperatures for the elements appearing in the sample are given by the following table.

Element	Ca	Fe	Si	Al	Pd	Rh
$T_B/^oC$	1420	1535	2355	2327	>2200	2500
Element	Ru	Pt	Ir	Os	Ag	Au
$T_B/^oC$	4150	4300	> 4800	> 5300	1950	2600

Table 2. Boiling temperatures of elements appearing in the samples of Hudson.

Hudson experimented also with commercially available samples of precious metals and found that the lines appear within 15 seconds, then follows a silence until lines re-appear after 90 seconds. Note that the ratio of these time scales is 6. The presence of some exotic form of these metals suggests itself: Hudson talks about mono-atomic elements.

Hudson studied specifically what he calls mono-atomic gold and claims that it does not possess metallic properties. Hudson reports that the weight of mono-atomic gold, which appears as a white powder, is 4/9 of the weight of metallic gold. Mono-atomic gold is claimed to behave like super-conductor.

Hudson does not give a convincing justification for why his elements should be mono-atomic so that in following this attribute will be used just because it represents established convention. Hudson also claims that the nuclei of mono-atomic elements are in a high spin state. I do not understand the motivations for this statement.

5.1.2 Claims of Hudson about ORMEs as super conductors

The claims of Hudson that ORMES are super conductors [85] are in conflict with the conventional wisdom about super conductors.

1. The first claim is that ORMEs are super conductors with gap energy about $\Delta = .05$ eV and identifies photons with this energy resulting from the formation of Cooper pairs. This energy happens to correspond one of the absorption lines in high T_c superconductors.

2. ORMEs are claimed to be super conductors of type II with critical fields H_{c1} and H_{c2} of order of Earth's magnetic field having the nominal value $.5 \times 10^{-4}$ Tesla [85]. The estimates for the critical parameters for the ordinary super conductors suggests for electronic super conductors critical fields, which are about .1 Tesla and thus by a factor $\sim 2^{11}$ larger than the critical fields claimed by Hudson.

3. It is claimed that ORME particles can levitate even in Earth's magnetic field. The latter claim looks at first completely nonsensical. The point is that the force giving rise to the levitation is roughly the gradient of the would-be magnetic energy in the volume of levitating super conductor. The gradient of average magnetic field of Earth is of order B/R, R the radius of Earth and thus extremely small so that genuine levitation cannot be in question.

5.1.3 Minimal model

Consider now a possible TGD inspired model for these findings assuming for definiteness that the basic Hudson's claims are literally true.

1. In what sense mono-atomic elements could be dark matter?

The simplest option suggested by the applicability of emission spectroscopy and chemical inertness is that mono-atomic elements correspond to ordinary atoms for which valence electrons are dark electrons with large $\hbar/\hbar_0 = n_a/n_b$. Suppose that the emission spectroscopy measures the energies of dark photons from the transitions of dark electrons transforming to ordinary photons before the detection by de-coherence increasing the frequency by the factor $r = \hbar/\hbar_0$. The size of dark electrons and temporal duration of basic processes would be zoomed up by r.

Since the time scale after which emission begins is scaled up by a factor 6, there is a temptation to conclude that $r = n_a/n_b = 6$ holds true. Note that $n = 6$ corresponds to Fermat polygon and is thus preferred number theoretically in TGD based model for preferred values of $\hbar$ [A9]. The simplest possibility is that the group G_b is trivial group and $G_a = A_6$ or D_6 so that ring like structures containing six dark atoms are suggestive.

This brings in mind the model explaining the anomalous conductivity of DNA by large $\hbar$ valence electrons of aromatic rings of DNA. The zooming up of spatial sizes might make possible exotic effects and perhaps even a formation of atomic Bose-Einstein condensates of Cooper pairs. Note however that in case of DNA $r = 6$ not gives only rise to conductivity but not super-conductivity and that $r = 6$ cannot explain the claimed very low critical magnetic field destroying the super-conductivity.

2. Loss of weight

The claimed loss of weight by a factor $p \simeq 4/9$ is a very significant hint if taken seriously. The proposed model implies that the density of the partially dark phase is different from that of the ordinary phase but is not quantitative enough to predict the value of p. The most plausible reason for the loss of weight would be the reduction of density induced by the replacement of ordinary chemistry with $\hbar/\hbar_0 = n_a/n_b = 6$ chemistry for which the Compton length of valence electrons would increase by this factor.

3. Is super-conductivity possible?

The overlap criterion is favorable for super-conductivity since electron Compton lengths would be scaled up by factor $n_a = 6, n_b = 1$. For $\hbar/\hbar_0 = n_a = 6$ Fermi energy would be scaled up by $n_a^2 = 36$ and if the same occurs for the gap energy, T_c would increase by a factor 36 from that predicted by the standard BCS theory. Scaled up conventional super-conductor having $T_c \sim 10$ K would be in question (conventional super-conductors have critical temperatures below 20 K). 20 K upper bound for the critical temperature of these superconductors would allow 660 K critical temperature for their dark variants!

For large enough values of n_a the formation of Cooper pairs could be favored by the thermal instability of valence electrons. The binding energies would behave as $E = (n_b/n_a)^2 Z_{eff}^2 E_0/n^2$, where Z_{eff} is the screened nuclear charge seen by valence electrons, n the principal quantum number for the valence electron, and E_0 the ground state energy of hydrogen atom. This gives binding energy smaller than thermal energy at room temperature for $n_a/n_b > (Z_{eff}/n)\sqrt{2E_0/3T_{room}} \simeq 17.4 \times (Z_{eff}/n)$. For $n = 5$ and $Z_{eff} < 1.7$ this would give thermal instability for $n_a = 6$.

Interestingly, the reported .05 eV infrared line corresponds to the energy assignable to cell membrane voltage at criticality against nerve pulse generation, which suggests a possible connection with high T_c superconductors for which also this line appears and is identified in terms of Josephson energy. .05 eV line appears also in high T_c superconductors. This interpretation does not exclude the interpretation as gap energy. The gap energy of the corresponding BCS super-conductor would be scaled down by $1/n_a^2$ and would correspond to 14 K temperature for $n_a = 6$.

Also high T_c super-conductivity could involve the transformation of nuclei at the stripes containing the holes to dark matter and the formation of Cooper pairs could be due to the thermal instability of valence electrons of Cu atoms (having $n = 4$). The rough extrapolation for the critical temperature for cuprate superconductor would be $T_c(Cu) = (n_{Cu}/n_{Rh})^2 T_c(Rh) = (25/36)T_c(Rh)$. For $T_c(Rh) = 300$ K this would give $T_c(Cu) = 192$ K: accoding to Wikipedia cuprate perovskite has the highest known critical temperature which is 138 K. Note that quantum criticality suggests the possibility of several values of (n_a, n_b) so that several kinds of super-conductivities might be present.

5.1.4 ORMEs as partially dark matter, high T_c super conductors, and high T_c superfluids

The appearance of .05 eV photon line suggest that same phenomena could be associated with ORMEs and high T_c super-conductors. The strongest conclusion would be that ORMEs are T_c super-conductors and that the only difference is that Cu having single valence electron is replaced by a heavier atom with single valence electron. In the following I shall discuss this option rather independently from the minimal model.

1. ORME super-conductivity as quantum critical high T_c superconductivity

ORMEs are claimed to be high T_c superconductors and the identification as quantum critical superconductors seems to make sense.

1. According to the model of high T_c superconductors as quantum critical systems, the properties of Cooper pairs should be more or less universal so that the observed absorption lines

discussed in the section about high T_c superconductors should characterize also ORMEs. Indeed, the reported 50 meV photon line corresponds to a poorly understood absorption line in the case of high T_c cuprate super conductors having in TGD framework an interpretation as a transition in which exotic Cooper pair is excited to a higher energy state. Also Copper is a transition metal and is one of the most important trace elements in living systems [47]. Thus the Cooper pairs could be identical in both cases. ORMEs are claimed to be superconductors of type II and quantum critical superconductors are predicted to be of type II under rather general conditions.

2. The claimed extremely low value of H_c is also consistent with the high T_c superconductivity. The supra currents in the interior of flux tubes of radius of order $L_w = .2$ μm are BCS type supra currents with large $\hbar$ so that T_c is by a factor 2^{11} higher than expected and H_c is reduced by a factor $2^{-11/2}$. This indeed predicts correct order of magnitude for the critical magnetic field.

3. $r = \hbar/\hbar_0 = 2^{11}$ is considerably higher that $r = 6$ suggested by the minimum model explaining emission spectroscopic results of Hudson. Of course, several values of $\hbar$ are possible and the values $r \in \{5, 6, 2^{k11}\}$ are indeed assumed in TGD inspired model of living matter and generalize EEG [M3]. Thus internal consistency would be achieved if ORMEs are regarded as a very simple form of living matter.

4. The electronic configurations of Cu and Gold are chemically similar. Gold has electronic configuration $[Xe, 4f^{14}5d^{10}]6s$ with one valence electron in s state whereas Copper corresponds to $3d^{10}4s$ ground state configuration with one valence electron. This encourages to think that the doping by holes needed to achieve superconductivity induces the dropping of these electrons to $k = 151$ space-time sheets and gives rise to exotic Cooper pairs. Also this model assumes the phase transition of some fraction of Cu nuclei to large $\hbar$ phase and that exotic Cooper pairs appear at the boundary of ordinary and large $\hbar$ phase.

   More generally, elements having one electron in s state plus full electronic shells are good candidates for doped high T_c superconductors. Both Cu and Au atoms are bosons. More generally, if the atom in question is boson, the formation of atomic Bose-Einstein condensates at Cooper pair space-time sheets is favored. Thus elements with odd value of A and Z possessing full shells plus single s wave valence electron are of special interest. The six stable elements satisfying these conditions are ^{5}Li, ^{39}K, ^{63}Cu, ^{85}Rb, ^{133}Cs, and ^{197}Au.

2. "Levitation" and loss of weight

The model of high T_c superconductivity predicts that some fraction of Cu atoms drops to the flux tube with radius $L_w = .2$ μm and behaves as a dark matter. This is expected to occur also in the case of other transition metals such as Gold. The atomic nuclei at this space-time sheet have high charges and make phase transition to large $\hbar$ phase and form Bose-Einstein condensate and superfluid behavior results. Electrons in turn form large $\hbar$ variant of BCS type superconductor. These flux tubes are predicted to be negatively charged because of the Bose-Einstein condensate of exotic Cooper pairs at the boundaries of the flux tubes having thickness $L(151)$. The average charge density equals to the doping fraction times the density of Copper atoms.

The first explanation would be in terms of super-fluid behavior completely analogous to the ability of ordinary superfluids to defy gravity. Second explanation is based on the electric field of Earth which causes an upwards directed force on negatively charged BE condensate of exotic Cooper pairs and this force could explain both the apparent levitation and partial loss of weight. The criterion for levitation is $F_e = 2eE/x \geq F_{gr} = Am_pg$, where $g \simeq 10$ m^2/s is gravitational acceleration at the surface of Earth, A is the atomic weight and m_p proton mass, E the strength of electric field, and x is the number of atoms at the space-time sheet of a given Cooper pair. The condition gives $E \geq 5 \times 10{-}10Ax$ V/m to be compared with the strength $E = 10^2 - 10^4$ V/m of the Earths' electric field.

An objection against the explanation for the effective loss of weight is that it depends on the strength of electric field which varies in a wide range whereas Hudson claims that the reduction factor is constant and equal to 4/9. A more mundane explanation would be in terms of a lower density of dark Gold. This explanation is quite plausible since there is no atomic lattice structure since nuclei and electrons form their own large $\hbar$ phases.

4. The effects on biological systems

Some monoatomic elements such as White Gold are claimed to have beneficial effects on living systems [85]. 5 per cent of brain tissue of pig by dry matter weight is claimed to be Rhodium and Iridium. Cancer cells are claimed to be transformed to healthy ones in presence of ORMEs. The model for high T_c super conductivity predicts that the flux tubes along which interior and boundary supra currents flow has same structure as neuronal axons. Even the basic length scales are very precisely the same. On basis of above considerations ORMEs are reasonable candidates for high T_c superconductors and perhaps even super fluids.

The common mechanism for high T_c, ORME- and bio- super-conductivities could explain the biological effects of ORMEs.

1. In unhealthy state superconductivity might fail at the level of cell membrane, at the level of DNA or in some longer length scales and would mean that cancer cells are not anymore able to communicate. A possible reason for a lost super conductivity or anomalously weak super conductivity is that the fraction of ORME atoms is for some reason too small in unhealthy tissue.

2. The presence of ORMEs could enhance the electronic bio- superconductivity which for some reason is not fully intact. For instance, if the lipid layers of cell membrane are, not only wormhole-, but also electronic super conductors and cancer involves the loss of electronic super-conductivity then the effect of ORMEs would be to increase the number density of Cooper pairs and make the cell membrane super conductor again. Similar mechanism might work at DNA level if DNA:s are super conductors in "active" state.

5. Is ORME super-conductivity associated with the magnetic flux tubes of dark magnetic field $B_d = 0.2$ Gauss?

The general model for the ionic super-conductivity in living matter, which has developed gradually during the last few years and will be discussed in detail later, is based on the assumption that super-conducting particles reside at the super-conducting magnetic flux tubes of Earth's magnetic field with nominal value $B_E = .5$ Gauss. It later became clear that the explanation of ELF em fields on vertebrate brain requires $B_d = .2$ Gauss rather than B_E as was erratically assumed in the original model. The interpretation was as dark magnetic field $B_d = .2$ Gauss.

The predicted radius $L_w = .2$ μm is consistent with the radius of neuronal axons. For $\hbar \rightarrow n \times 2^{11}\hbar$, $n = 3$, the radius is 1.2 μm and still smaller than the radius d of flux tube of B_E of order $d = 5$ μm and scales up as $d \rightarrow \sqrt{B_d/B_E}\sqrt{r}d = \sqrt{5r/2}d$ in the replacement $\hbar/\hbar_0 \rightarrow r$, $B_E \rightarrow B_d$. Consistency is achieved even for $r = 1$ and for $r = 6$ the radius corresponds to the size of large neuron. The most natural interpretation would be that these flux tubes topologically condense at the flux tubes of B_d or B_E. Both bosonic ions and the Cooper pairs of electrons or of fermionic ions can act as charge carriers so that actually a whole zoo of super-conductors is predicted. There is even some support for the view that even molecules and macromolecules can drop to the magnetic flux tubes [K6].

5.1.5 Consciousness related claims

If mono-atomic elements represent dark or partially dark matter with suggested properties, the claimed finding by Hudson that 5 per cent of brain tissue of pig by dry matter weight is Rhodium and Iridium might be understood.

In order to not induce un-necessary negative reactions in materialistic readers, I have purposefully left out Hudson's references to alchemy and Biblical stories. These references admittedly begin to make sense for an open minded reader if dark matter serves as a kind of elixir of life or philosopher's stone. If there exists an infinite hierarchy of conscious entities, it would not be difficult to accept that alchemists (Newton being one of them) would have had precognition about the existence of dark matter and its significance for life.

5.1.6 Possible implications

The existence of exotic atoms could have far reaching consequences for the understanding of bio-systems. If Hudson's claims about super-conductor like behavior are correct, the formation of exotic atoms in bio-systems could provide the needed mechanism of electronic super-conductivity. One could even argue that the formation of exotic atoms is the magic step transforming chemical evolution to biological evolution.

Equally exciting are the technological prospects. If the concept works it could be possible to manufacture exotic atoms and build room temperature super conductors and perhaps even artificial life some day. It is very probable that the process of dropping electron to the larger space-time sheet requires energy and external energy feed is necessary for the creation of artificial life. Otherwise the Earth and other planets probably have developed silicon based life for long time ago. Ca, K and Na ions have central position in the electrochemistry of cell membranes. They could actually correspond to exotic ions obtained by dropping some valence electrons from $k = 137$ atomic space-time sheet to larger space-time sheets. For instance, the $k = 149$ space-time sheet of lipid layers could be in question.

The status of ORMEs is far from certain and their explanation in terms of exotic atomic concept need not be correct. The fact is however that TGD predicts exotic atoms: if they are not observed TGD approach faces the challenge of finding a good explanation for their non-observability.

5.2 Connection with cold fusion?

The basic prediction of TGD is a hierarchy of fractally scaled variants of non-asymptotically free QCD like theories and that color dynamics is fundamental even for our sensory qualia (visual colors identified as increments of color quantum numbers in quantum jump). The model for ORMEs suggest that exotic protons obey QCD like theory in the size scale of atom. If this identification is correct, QCD like dynamics might be studied some day experimentally in atomic or even macroscopic length scales of order cell size and there would be no need for ultra expensive accelerators! The fact that Palladium is one of the "mono-atomic" elements used also in cold fusion experiments as a target material [65, 64] obviously puts bells ringing.

5.2.1 What makes possible cold fusion?

I have proposed that cold fusion might be based on Trojan horse mechanism in which incoming and target nuclei feed their em gauge fluxes to different space-time sheets so that electromagnetic Coulomb wall disappears [F8]. If part of Palladium nuclei are "partially dark", this is achieved. Another mechanism could be the de-localization of protons to a larger volume than nuclear volume induced by the increase of $\hbar_{eff}$ meaning that reaction environment would differ dramatically from that appearing in the usual nuclear reactions and the standard objections against cold fusion would not apply anymore [F8]: this delocalization could correspond to the darkness of electromagnetic field bodies of protons.

A third proposal is perhaps the most elegant and relies on the nuclear string model [F9] predicting a large number of exotic nuclei obtained by allowing the color bonds connecting nucleons to have all possible em charges $1, 0, 1$. Many ordinary heavy nuclei would be exotic in the sense that some protons would correspond to protons plus negatively charged color bonds. The exchange of an exotic weak boson between D and Pd nuclei transforming D nuclei to exotic neutral D nuclei would occur. The range of the exotic weak interaction correspond to atomic length scale meaning that it behaves as massless particle below this length scale. For instance, W boson could be $n = 2^{11}$ dark variant of $k = 113$ weak boson but also other options are possible.

5.2.2 How standard objections against cold fusion can be circumvented?

The following arguments against cold fusion are from an excellent review article by Storms [61].

1. Coulomb wall requires an application of higher energy. Now electromagnetic Coulomb wall disappears in both models.

2. If a nuclear reaction should occur, the immediate release of energy can not be communicated to the lattice in the time available. In the recent case the time scale is however multiplied by the factor $r = n_a$ and the situation obviously changes. For $n_a = 2^{11}$ the time scale corresponding to MeV energy becomes that corresponding to keV energy which is atomic time scale.

3. When such an energy is released under normal conditions, energetic particles are emitted along with various kinds of radiation, only a few of which are seen by various CANR (Chemically Assisted Nuclear Reactions) studies. In addition, gamma emission must accompany helium, and production of neutrons and tritium, in equal amounts, must result from any fusion reaction. None of these conditions is observed during the claimed CANR effect, no matter how carefully or how often they have been sought. The large value of $\hbar(M^4)$ implying large Compton lengths for protons making possible geometric coupling of gamma rays to condensed matter would imply that gamma rays do not leave the system. If only protons form the quantum coherent state then fusion reactions do not involve the protons of the cathode at all and production of ^3He and thus of neutrons in the fusion of D and exotic D.

4. The claimed nuclear transmutation reactions (reported to occur also in living matter [62]) are very difficult to understand in standard nuclear physics framework.

   i) The model of [F8] allows them since protons of different nuclei can re-arrange in many different manners when the dark matter state decays back to normal.

   ii) Nuclear string model [F9] allows transmutations too. For instance, neutral exotic tritium produced in the reactions can fuse with Pd and other nuclei.

5. Many attempts to calculate fusion rates based on conventional models fail to support the claimed rates within PdD (Palladium-Deuterium). The atoms are simply too far apart. This objections also fails for obvious reasons.

5.2.3 Mechanisms of cold fusion

One can deduce a more detailed model for cold fusion from observations, which are discussed systematically in [61] and in the references discussed therein.

1. A critical phenomenon is in question. The average D/Pd ratio must be in the interval $(.85, .90)$. The current must be over-critical and must flow a time longer than a critical time. The effect occurs in a small fraction of samples. D at the surface of the cathode is found to be important and activity tends to concentrate in patches. The generation of fractures leads to the loss of the anomalous energy production. Even the shaking of the sample can have the same effect. The addition of even a small amount of H_2O to the electrolyte (protons to the cathode) stops the anomalous energy production.

   i) These findings are consistent the view that patches correspond to a macroscopic quantum phase involving delocalized nuclear protons. The added ordinary protons and fractures could serve as a seed for a phase transition leading to the ordinary phase [F8].

   ii) An alternative interpretation is in terms of the formation of neutral exotic D and exotic Pd via exchange of exotic, possibly dark, W bosons massless below atomic length scale [F9].

2. When D_2O is used as an electrolyte, the process occurs when PdD acts as a cathode but does not seem to occur when it is used as anode. This suggests that the basic reaction is between the ordinary deuterium $D = pn$ of electrolyte with the exotic nucleus of the cathode. Denote by $\hat{p}$ the exotic proton and by $\hat{D} = n\hat{p}$ exotic deuterium at the cathode.

   For ordinary nuclei fusions to tritium and ^3He occur with approximately identical rates. The first reaction produces neutron and ^3He via $D + D \rightarrow n +^3 He$, whereas second reaction produces proton and tritium by $3H$ via $D + D \rightarrow p +^3 H$. The prediction is that one neutron per each tritium nucleus should be produced. Tritium can be observed by its beta decay to ^3He and the ratio of neutron flux is several orders of magnitude smaller than tritium flux as found for instance by Tadahiko Mizuno and his collaborators (Mizuno describes the experimental process leading to this discovery in his book [66]). Hence the reaction producing ^3He cannot occur significantly in cold fusion which means a conflict with the basic predictions of the standard nuclear physics.

   i) The explanation discussed in [F8] is that the proton in the target deuterium $\hat{D}$ is in the exotic state with large Compton length and the production of ^3He occurs very slowly since $\hat{p}$ and p correspond to different space-time sheets. Since neutrons and the proton of the D from the electrolyte are in the ordinary state, Coulomb barrier is absent and tritium production can occur. The mechanism also explains why the cold fusion producing ^3He and neutrons does not occur using water instead of heavy water.

   ii) Nuclear string model [F9] model predicts that only neutral exotic tritium is produced considerably when incoming deuterium interacts with neutral exotic deuterium in the target.

3. The production of ^4He has been reported although the characteristic gamma rays have not been detected.

   i) ^4He can be produced in reactions such as $D + \hat{D} \rightarrow^4 He$ in the model of [F8].

   ii) Nuclear string model [F8] does not allow direct production of ^4He in D-D collisions.

4. Also more complex reactions between D and Pd for which protons are in exotic state can occur. These can lead to the reactions transforming the nuclear charge of Pd and thus to nuclear transmutations.

   Both model explain nuclear transmutations. In nuclear string model [F8] the resulting exotic tritium can fuse with Pd and other nuclei and produce nuclear transmutations.

   The reported occurrence of nuclear transmutation such as $^{23}Na+^{16}O \rightarrow^{39} K$ in living matter [62] allowing growing cells to regenerate elements K, Mg, Ca, or Fe, could be understood in nuclear string model if also neutral exotic charge states are possible for nuclei in living matter. The experimental signature for the exotic ions would be cyclotron energy spectrum containing besides the standard lines also lines with ions with anomalous mass number. This could be seen as a splitting of lines. For instance, exotic variants of ions such Na^+, K^+, Cl^-, Ca^{++} with anomalous mass numbers should exist. It would be easy to mis-interpret the situation unless the actual strength of the magnetic field is not checked.

5. Gamma rays, which should be produced in most nuclear reactions such as ^4He production to guarantee momentum conservation are not observed.

   i) The explanation of the model of [F8] is that the recoil momentum goes to the macroscopic quantum phase and eventually heats the electrolyte system. This provides obviously the mechanism by which the liberated nuclear energy is transferred to the electrolyte difficult to imagine in standard nuclear physics framework.

   ii) In nuclear string model [F9] ^4He is not produced at all.

6. Both models explain why neutrons are not produced in amounts consistent with the anomalous energy production. The addition of water to the electrolyte is however reported to induce neutron bursts.

   i) In the model of [F8] a possible mechanism is the production of neutrons in the phase transition $\hat{p} \rightarrow p$. $\hat{D} \rightarrow p+n$ could occur as the proton contracts back to the ordinary size in such a manner that it misses the neutron. This however requires energy of 2.23 MeV if the rest masses of $\hat{D}$ and D are same. Also $\hat{D} + \hat{D} \rightarrow n +^3 He$ could be induced by the phase transition to ordinary matter when $\hat{p}$ transformed to p does not combine with its previous neutron partner to form D but recombines with $\hat{D}$ to form $^3\hat{He} \rightarrow^3 He$ so that a free neutron is left.

   ii) Nuclear string model [F9] would suggest that the collisions of protons of water with exotic D produce neutron and ordinary D. This requires the transformation of negatively charged color bond between p and n of target D to a neutral color bond between incoming p and neutron of target.

5.3 Connection with sono-luminescence and sono-fusion?

Sono-luminescence [80] is a poorly understood phenomenon in which the compression of bubbles in liquid leads to very intense emission of photons and generation of temperatures which are so high that even nuclear fusion might become possible. Sono-fusion [67] is a second closely related poorly understood phenomenon. I have discussed a TGD inspired model for sono-luminescence in [F10] in terms of p-adic length scale hypothesis.

In bubble compression the density of matter inside bubble might become so high that the Compton lengths associated with possibly existing conformally confined phases inside nuclei could start to overlap and a delocalized phase of protons and/or neutrons could form and em and Z^0 Coulomb walls could disappear. Cold fusion would occur and the energy produced would explain the achieved high temperatures and sono-luminescence. Thus the causal relation would be reversed from what it is usually believed to be. The same anomalies are predicted as in the case of cold fusion also now.

Bubble compression brings in mind "mini crunch" occurring also in RHIC experiments, and p-adic fractality suggests that analogy might be rather precise in that magnetic flux tubes structure carrying Bose-Einstein condensate of protons, electrons and photons might form. The intense radiation of photons might be an analog of thermal radiation from an evaporating black hole. The relevant p-adic scale is probably not smaller than 100 nm, and this would give Hagedorn temperature which is around $T_H \sim 10$ eV for ordinary Planck constant and much smaller than fusion temperature. For $\hbar_s$ the Hagedorn temperature would be scaled up to $T_H \sim rT_H$, $r = \hbar_s/\hbar$. For $r = 10^5$ temperatures allowing nuclear fusion would be achieved.

6 Dark atomic physics

Dark matter might be relevant also for atomic physics and in the sequel some speculations along these lines are represented. Previous considerations assumed that only field bodies can be dark. The notion of N-atom discussed below is based on more general view about dark matter not requiring that elementary particles are maximally quantum critical in the sense that elementary particle like partonic 2-surfaces remain invariant under the cyclic groups $G_a \times G_b$ leaving invariant the choice of the quantization axes. Therefore the sheets of space-time surface associated with the sheets of the multiple coverings $H \to H/G_a \times G_b$ do not co-incide and can carry fermionic quantum numbers. The minimum option is that fermion states possibly associated with different sheets are identical so that an apparent failure of Fermi statistics would result. The additional degree of freedom would correspond to an element of group algebra of $G_a \times G_b$ for a given many-fermion state. The more general option allowing different fermion quantum numbers is not consistent with quantum classical correspondence in its strongest form.

6.1 From naive formulas to conceptualization

I have spent a considerable amount of time on various sidetracks in attempts to understand what the quantization of Planck constant does really mean. As usual, the understanding has emerged by unconscious processing rather than by a direct attack.

6.1.1 Naive approach based on formulas

The whole business started from the naive generalization of various formulas for quantized energies by replacing Planck constant with is scaled value. It seems that this approach does not lead to wrong predictions, and is indeed fully supported by the basic applications of the theory. Mention only the quantization of cyclotron energies crucial for the biological applications, the quantization of hydrogen atom, etc... The necessity for conceptualization emerges when one asks what else the theory predicts besides the simple zoomed up versions of various systems.

6.1.2 The geometric view about the quantization of Planck constant

After the naive approach based on simple substitutions came the attempt to conceptualize by visualizing geometrically what dark atoms could look like, and the description in terms of $N(G_a) \times N(G_b)$-fold covering $H \to H/G_a \times G_b$ emerged.

Especially confusing was the question whether one should assign Planck constant to particles or to their interactions or both. It is now clear that one can assign Planck constant to both the "personal" field bodies assignable to particles and to their interactions ("relative" or interaction field bodies), and that each interaction can correspond to both kinds of field bodies. Planck constant for the relative field bodies depends on the quantum numbers of both particles as it does in the case of gravitation. The Planck constant assignable to the particle's "personal" field body makes possible generalizations like the notion of N-atom.

Each sheet of the "personal" field body corresponds to one particular Compton length characterizing one particular interaction and electromagnetic interaction would define the ordinary Compton length. The original picture was that topological condensation of CP_2 type vacuum extremal occurs at space-time sheet with size of Compton length identified usually with particle. In the new picture this space-time sheet can be identified as electromagnetic field body.

Elementary particles have light-like partonic 3-surfaces as space-time correlates. If these 3-surfaces are fully quantum critical, they belong to the intersection of all spaces $H/G_a \times G_b$ with fixed quantization axes. This space is just the 4-D subspace $M^2 \times S^2 \subset M^4 \times CP_2$, where S^2 is geodesic sphere of CP_2. Partonic 2-surfaces are in general non-critical and one can assign to them a definite value of Planck constant.

There are two geodesic spheres in CP_2. Which one should choose or are both possible?

1. For the homologically non-trivial one corresponding to cosmic strings, the isometry group is $SU(2) \subset SU(3)$. The homologically trivial one S^2 corresponds to vacuum extremals and has isometry group $SO(3) \subset SU(3)$. The natural question is which one should choose. At quantum criticality the value of Planck constant is undetermined. The vacuum extremal would be a natural choice from the point of view of quantum criticality since in this case the value of Planck constant does not matter at all and one would obtain a direct connection with the vacuum degeneracy. One can of course ask whether all surfaces $M^2 \times Y^2$, Y^2 Lagrangian sub-manifold of CP_2 should be allowed: the answer seems to be "No" since in the generic case $SO(3)$ does not act as H-isometries of Y^2.

2. The choice of the homologically non-trivial geodesic sphere as a quantum critical sub-manifold would conform with the previous guess that $\mathcal{M} : \mathcal{N} = 4$ corresponds to cosmic strings. It is however questionable whether the ill-definedness of the Planck constant is consistent with the non-vacuum extremal property of cosmic strings unless one assumes that for partonic 3-surfaces $X^3 \subset M^2 \times S^2$ the effective degrees of freedom reduce to mere topological ones.

6.1.3 Fractionization of quantum numbers and the hierarchy of Planck constants

The original generalization of the notion of imbedding space to a union of the factor spaces $\hat{H}/G_a \times G_b$ discussed in the section "General ideas about dark matter" does not allow charge fractionization whereas the covering spaces $\hat{H}\hat{\times}(G_a \times G_b)$ allow a fractionization in a natural manner. Also hybrid cases are obtained corresponding $(\hat{M}^4\hat{\times}G_a) \times (\hat{CP}_2/G_b)$ and $(\hat{M}^4/G_a) \times (\hat{CP}_2\hat{\times}G_b)$. The simplest assumption is that Planck constant is a homomorphism from the lattice like structure of groups with product of groups defined to be the group generated by the groups.

1. $\hat{H}/G_a \times G_b$ option

The safest and indeed natural assumption motivated by Jones inclusions is that physical states in sector $H/G_a \times G_b$ are $G_a \times G_b$ invariant meaning a discrete analog of color confinement. This alone excludes fractionization and actually implies just the opposite of it.

1. For states with vanishing fermionic quantum numbers $G_a \times G_b$ invariance means that wave functions live in the base space $H/G_a \times G_b$. For instance, L_z would be a multiple of n_a defining the order of maximal cyclic subgroup of G_a. Analogous conclusion would hold true for color quantum numbers.

2. Just as in the case of ordinary spin fermionic quantum numbers (spin, electro-weak spin) necessarily correspond to the covering group of the isometry group since a state with a half-odd integer spin does not remain invariant under the subgroups of the rotation group. In particular, states with odd fermion number cannot be $G_a \times G_b$ invariant. For even fermion numbers it is possible to have many-particle states for which individual particles transform non-trivially under orbital $G_a \times G_b$ if total $G_a \times G_b$ quantum numbers in spin like degrees of freedom compensate for the orbital quantum numbers (for instance, total spin is multiple of n_a). Hence the group algebra of $G_a \times G_b$ would characterize the states in orbital degrees of freedom as indeed assumed. The earlier picture would be correct apart from the lacking assumption about overall $G_a \times G_b$ invariance.

3. The construction of these states could be carried out just like the construction of ordinary $G_a \times G_b$ invariant states in H so that the mathematical treatment of the situation involves

no mystics elements. Since $G_a \times G_b$ is actually assigned with a sector $M^4_\pm \times CP_2$ with fixed quantization axes and preferred point of H, one has center of mass degrees of freedom for the position of tip of $M^4_\pm$ and a preferred point of CP_2. This gives new degrees of freedom and one would have a rich spectrum of N-electrons, N-nucleons, N-atoms, etc.... behaving effectively as elementary particles. For example, one interesting question is whether 2-electrons could be interpreted as Cooper pairs of particular kind This would require either $s_z = 0, l_z = 0$ or $s_z = 1, l_z = mn_a - 1$, $m = 0, 1, 2...$ For instance, for $n_a = 3$ (the minimal value of n_a) one could have $s_z = l, l_z = 2$ with $J_z = 3$. One can also ask whether some high spin nuclei could correspond to N-nuclei.

4. This picture is quite predictive. For instance, in the case of gravitational interactions it would mean that the spin angular momentum of an astrophysical system is a multiple of "personal" gravitational Planck constant GM^2/v_0. The value of v_0 could be deduced from this condition and is expected to be a negative power of 2. In the same manner the relative angular momentum of planet-Sun system would be a multiple of GMm/v_0 using the gravitational Planck constant as a unit. This is a strong prediction but reduces to the Bohr quantization rule for circular orbits.

2. $\hat{H}\hat{\times}(G_a \times G_b)$ option

For this option the units of orbital angular momentum and color hyper charge and isospin are naturally scaled down by the factor n_i. In the case of spin and electro-weak spin this kind of scaling would require a covering group of Abelian Cartan group. Since the first homotopy group of SU(2) vanishes there are no coverings of $SU(2)$ in the ordinary sense of the word but quantum version of $SU(2)$ is an excellent candidate for the counterpart of the covering. Also quantum variants of other Lie groups are highly suggestive on basis of ADE correspondence.

There does not seem to be any absolute need for assuming $G_a \times G_b$ singletness. If so, there would be asymmetry between coverings and factor spaces bringing in mind confined and de-confined phases. Since coverings *resp.* factor spaces are labelled by N^{11}-valued lattice momenta *resp.* their negatives, this asymmetry would be analogous to time reversal asymmetry. Note however that all components of lattice momenta are either positive or negative and that this fits nicely with the interpretation of p-adic integers as naturals and "super-naturals". An intriguing question is whether there might be some connection with M-theory and its 4-D compactifications (dropping reflection group one obtains 7-D lattice).

3. Implications of the new picture

This picture has several important implications.

1. There is a symmetry between CP_2 and M^4 so that for a given value of Planck constant one obtains factor space with divisor group $G_a \times G_b$ and covering space with homotopy group $G_b \times G_a$. For large values of Planck constant the large Z_n symmetry acts in M^4 factor *resp.* CP_2 factor for these two options. Therefore the large Z_n symmetry in M^4 degrees of freedom, which can be challenged in some of the applications, could be replaced with large Z^n symmetry in CP_2 degrees of freedom emerging rather naturally.

2. For a large value of Planck constant it is possible to obtain a relatively small dark matter symmetry group in M^4 factor and also the small genuinely 3-dimensional symmetry groups (tedrahedral, octahedral, icosahedral groups) can act in M^4 factor as symmetries of dark matter. Hence the groups appearing as symmetries of molecular physics (aromatic rings, DNA,...) could be identified as symmetries of dark electron pairs. These symmetries appear also in longer length scales (snow flakes and even astrophysical structures). In earlier picture one had to assume symmetry breaking at the level of visible matter.

3. The notion of N-atom generalizes. The original model predicted large electronic charges suggesting instability plus large Z_n symmetry in M^4 degrees of freedom (identified as a symmetry of field body). For instance, in the case of DNA double helix this kind of large rotational symmetry is questionable. Same applies to astrophysical systems with a gigantic value of gravitational Planck constant. The change of the roles of M^4 and CP_2 and charge fractionization would resolve these problems. This would provide a support for the idea that the electronic or protonic hot spots of catalyst and substrate correspond to fractional charges summing up to a unit charge. This framework could provide a proper realization for the original vision that symbolic level of dynamics and sex emerge already at the molecular level with sequences of catalyst sites representing "words" and their conjugates (opposite molecular sexes).

6.2 Dark atoms and dark cyclotron states

The development of the notion of dark atom involves many side tracks which make me blush. The first naive guess was that dark atom would be obtained by simply replacing Planck constant with its scaled counterpart in the basic formulas and interpreting the results geometrically. After some obligatory twists and turns it became clear that this assumption is indeed the most plausible one. The main source of confusion has been the lack of precise view about what the hierarchy of Planck constants means at the level of imbedding space at space-time.

6.2.1 The assumptions of the model of dark atom

Let us briefly summarize the basic assumptions of the model.

1. The quantized values of effective Planck constant appearing in Schrödinger equation are in the set $\hbar_{eff}/\hbar_0 \in \{n_a/n_b, n_b/n_a, n_a n_b, 1/(n_a n_b)$ corresponding to the sectors $\hat{H}/G_a \times G_b$, $\hat{H}\hat{\times}(G_a \times G_b)$, $\hat{M}^4/G_a \times (\hat{CP}_2\hat{\times})G_b$, and $(\hat{M}^4\hat{\times}G_a) \times \hat{CP}_2/G_b$. Note that one can consider the replacement of the right hand side of the formula for Planck constant by its inverse, and at this stage one must just keep mind open for the options.

2. In the case of covering spaces the units of quantum numbers are replaced by $1/n_a$ and $1/n_b$, n_i the order of maximal cyclic subgroup. Both fermion number, spin, color, and electro-weak quantum numbers can fractionize. For factor spaces units are inverses of these and in this case states are $G_a \times G_b$ singlets: hence N-atoms with dark electrons in general involve many-electron states with even number of electrons. Simplest situation corresponds to spin singlet electron pair and one cannot exclude the possibility that valence electrons are dark electrons.

3. It is assumed that the quantum critical sub-manifolds $M^2 \times S^2$ correspond to homologically trivial geodesic sphere. Note that although quantum critical parton orbits are vacuum extremals, induced electric and Z^0 fields are non-vanishing in general. This is a very important point since it makes possible electric and magnetic fluxes between different sectors of the generalized imbedding space H. For instance, nucleus and electrons can belong to different sectors of H. A helpful visualization is provided by a book with pages glued together along $M^2 \times S^2$. Both electric and magnetic flux are assumed to be conserved as it flows from a sector to another one: therefore dark electron in the covering experiences the electric charge of nucleus as scaled down by a factor $1/N(G_b)$ giving the number of sectors.

4. In the case of factor spaces 3-surface is invariant under G_i so that one has $N(G_i)$ strict copies of the particle: G_i invariance selects states with $l_z = nn_a$ and forces many electron states in order to satisfy quantization conditions in the case of spin. Here one can consider the

possibility that single particle states transform according to irreducible representations of G_i although the entire state is G_i invariant.

5. In the case of covering spaces there is no need to assume that partonic 3-surface consists of $N(G_i)$ identical copies. In this case the states are naturally classified by the representations of $G_a \times G_b$ identifiable as elements of the corresponding group algebra. Apparently one has a modified statistics since $N(G_a) \times N(G_b)$ states correspond to the same state in the ordinary sense of the word. It can happen that the action of G_i in H has some isotropy subgroup. In fact, the action of D_{2n} in M^2 and S^2 reduces to the action of the corresponding cyclic group Z_n so that has $N(G_i) = n_i$.

6. One can consider quite a number of variants for the dark atom. Even nucleus could be dark (either fractionally charged or N-nucleus with charge $N(G_b)$). Second interesting possibility is atom with ordinary nucleus and dark electrons. It is also possible that only valence electrons are dark and correspond to one of the allowed varieties.

6.2.2 Thermal stability

The energy scale of hydrogen atom is proportional to $1/\hbar^2$. Depending on the sector of H and on the values of n_a and n_b the scale of energy can increase or be reduced. Also charge fractionization in case of covering spaces of $\hat{CP_2}$ reduces the energy scale. By the conservation of electric flux this takes place for both proton and electron so that the energy scale receives a factor $1/N(G_b)^2$. For large values of Planck constant the energy scale is reduced and thermal stability poses upper limit on the value of Planck constant if dark matter is assumed to be in thermal equilibrium with ordinary matter.

The following table lists the four possible options.

I	II	III	IV
$\hat{H}\hat{\times}G_a \times G_b$	$\hat{H}/(G_a \times G_b)$	$(\hat{H}/G_a)\hat{\times}G_b$	$(\hat{H}/G_b)\hat{\times}G_a$

One can also consider two options for the formula of Planck constant.

1. For $\hbar/\hbar_0 = n_a/n_b$ in case of option I and $G_b = Z_n$ thermal stability condition boils down to the condition

$$\begin{array}{ll} I: & Z \geq \frac{n_b^3}{n_a} \times x \ , \\ II: & Z \geq \frac{n_a}{n_b} \times x \ , \\ III: & Z \geq n_a n_b^3 \times x \ , \\ IV: & Z \geq \frac{1}{n_a n_b} \times x \ . \end{array} \quad x \equiv \sqrt{\frac{E_{th}}{E_1}} \ . \tag{2}$$

   Here E_{th} denotes thermal energy. Note that option III maximizes Planck constant for given $G_a \times G_b$ and is therefore especially interesting. Option IV minimizes in turn minimizes it.

   By replacing the formula for Planck constant with its inverse ($\hbar/\hbar_0 = n_b/n_a$ for option I) one obtains the conditions

$$\begin{array}{ll} I: & Z \geq n_b^2 n_a \times x \ , \\ II: & Z \geq \frac{n_b}{n_a} \times x \ , \\ III: & Z \geq \frac{n_b^3}{n_a} \times x \ , \\ IV: & Z \geq n_a n_b \times x \ . \end{array} \quad x \equiv \sqrt{\frac{E_{th}}{E_1}} \ . \tag{3}$$

Recall that the preferred values of n_a and n_b correspond to the number theoretically simple quantum phases $exp(i2\pi/n_i)$ expressible using only square root function and rational functions applied on rationals. n_i are given as products $2^k \times \prod_i F_i$, where F_i are distinct Fermat primes.

2. The original proposal for the hierarchy of Planck constants coming as $\hbar/\hbar_0 = \lambda = 2^{11k}$ does not allow stable hydrogen atom at room temperature. This is not a problem since this hierarchy is associated with cyclotron energies.

3. For option I with $n_a = 1$ and $n_b \in \{3, 5, 6, 12\}$ one would have $Z \geq z \in \{1, 6, 10, 81\}$. Carbon atom would satisfy the condition fors $(n_b = 5, n_a = 1)$ and $(n_b = 6, n_a = 2)$.

4. For option II with $n_b = 1$ one obtains $Z \geq n_a$ for $E_{th} \sim E_1$. What is intriguing that aromatic carbon 5- and 6-cycles, which are abundant in biology and correspond to factor space option, would satisfy this condition for $E_{th} \sim E_1$. For $n > 6$-cycles the condition would not be satisfied. Could this condition state something non-trivial about pre-biotic evolution at high temperatures?

5. For option III with $n_b = 3$ meaning charge fractionization and n_a-fold cyclic symmetry one obtains $Z \geq n_a \times 1.3$ at room temperature. For $n_b = 3$ 5-cycles with $\hbar/\hbar_0 = 15$ and 6-cycles with $\hbar/\hbar_0 = 18$ would be stable below room temperature but not higher cycles. This estimate is of course very rough since the energy scale E_1 for possibly dark delocalized free electron pairs appearing in n-cycles need not be exactly equal to E_1.

6. If one replaces the right hand side by its inverse in the expression of Planck constant the factor space option would favor the thermal stability for large values of n_a and n-cycles with large n so that this option does not look reasonable.

6.2.3 Is the fractionization of principal quantum number possible?

One can also consider the fractionization $n \to n/n_b$ of the principal quantum number of hydrogen analogous to that occurring for angular momentum. If one assumes that fractionization occurs only for isometry charges this option is excluded. This argument might quite well be enough to exclude this kind of fractionization.

Since s-wave states correspond to orbits which represent radial motion between two extremes, one could consider the possibility of periodic radial orbits which run to maximal radius, back to the maximum radius at the opposite side and close after N_b loops of this kind, where N_b is the order of maximal cyclic subgroup of G_b. This would be direct a counterpart for a rotational orbit which closes only after N_b full 2π rotations.

One can consider the occurrence of this phenomenon also in the case of ordinary imbedding space. At least inn this case the interpretation in terms of a transition to chaos might be appropriate. In case of generalized imbedding space one could speak about transition to chaos by period N_b-folding and suggest fractionization of the radial quantum number to n/N_b. Similar fractionization could makes sense for all orbits which are not precisely circular. This fractionization would increase the energy scale by a factor n_b^2.

In empty space fractional diagonal quantum number would mean that ordinary hydrogen atom wave functions diverge at spatial infinity. This kind of scaling is consistent with finiteness inside dark sector if the copies of sheet fuse together at at 3-surface belonging to the quantum critical manifold $M^2 \times S^2$.

6.2.4 Possible experimental implications

An interesting possibility is the formation of stable hydrogen bonds as a fusion of N-hydrogen atoms with $N-k$ and k electrons to give rise to a full shell of electrons possessing an exceptional stability.

1. In the case of factor space the state would be analogous to full Fermi sea or full atomic or nuclear shells. The large value of electric charge might make the state unstable. The resulting state would be invariant under $G_a \times G_b$.

2. For covering space option the total quantum numbers for the resulting state would be those of electron. The degeneracy of states is $N(G_a) \times N(G_b)$-fold corresponding to the group algebra of $G_a \times G_b$. This would mean that the full shell for states with given energy E_n would have total energy $n_a n_b E_n$.

Consider next the possible experimental implications of N-atom concept.

1. Valence electrons could transform to dark electrons in one of the four possible senses.

   i) For covering space option fractal electrons could result. Fractal electron and its conjugate would combine to form a particle with quantum numbers of electrons but with larger mass. Catalytic sites are one possible candidate for fractal electrons and catalyst activity could be understood as a strong tendency of fractal electron and its conjugate to fuse to form an ordinary electron. The anomalously high mass would be the tell-tale signature of these exotic electrons. The effective mass of electron in condensed matter is known to vary in wide limits and to exceed electron mass even by a factor of order hundred: is this really a mere standard physics effect?

   ii) For factor space option full electron shells would be the most stable states and would have have rather high fermion number but vanishing spin. Spin singlet electron pairs would define stable $G_a \times G_b$ singlets. These states might behave like Cooper pairs.

   iii) If the value of Planck constant is smaller than its standard value, the molecular bonds containing dark electrons could be stable at anomalously high temperatures. Note that the dependence of the bond energy on Planck constant need not be non-perturbative as it is for atoms. For instance, a naive application of the formulas for vibrational and rotational energies assuming that the parameters of Hamiltonian (such as vibrational energy scale) do not depend on Planck constant would suggest that large Planck constant implies thermal stability in this kind of situations.

   iv) Both fermionic a (Na^+, K^+, Cl^-) and bosonic (Ca^{++}, Mg^{++}) ions are very important in biology. Optimist would interpret this as a support for the plasmoids as predecessors of biological life. These ions are formed in some manner and the simplest manner would be transformation of valence electrons to dark electrons and subsequence delocalization.

2. The recently discovered evidence [84] that Sun has a solid surface consisting mostly of calcium-ferrite is inconsistent with the fact that photosphere has temperature 5800 K (iron melts at 1811 K and calcium-aluminium ferrite in the range 1670-1720 K at normal pressure). Metallic bonds responsible for the solid state are due to the interaction of delocalized conduction electrons with metal atoms. If the valence electrons giving rise to conduction bands have a reduced value of Planck constant, the energy scale of the valence bands would become higher and raise the melting temperature. The reduction of Planck constant seems necessary by the non-perturbative dependence of atomic binding energies on $\hbar$.

3. The claims of Mills [82] about the scaling up of the binding energy of the hydrogen ground state by a square k^2 $(k = 2, 3, 4, 5, 6, 7, 10)$ of an integer in plasma state are a challenge for the theory. The simplest explanation is that the Planck constant is reduced by factor $1/k$.

Before I had realized that $\hbar_{eff}$ satisfies the formula $\hbar_{eff}/\hbar_0 = n_a/n_b$, the presence of $k = 2$ state in spectrum was a difficult problem and I ended up with the idea that the quantum variant of Laguerre polynomials associated with quantized radial motion could explain $n = 1/2$ and also other fractional states. Later it will be found that this approach indeed predicts these quantum numbers approximately! This raises the question whether these states might appear as metastable intermediate states for hydrogen atom in the phase having $\hbar_{eff}/\hbar_0 = 1$ and $n_a = n_b > 1$. These states would be unstable against the phase transition leading to $n_b > kn_a$, $k = 2, 3, ...$

Living matter could perhaps be understood in terms of quantum deformations of the ordinary matter, which would be characterized by the quantum phases $q = exp(i2\pi/N)$. Hence quantum groups, which have for long time suspected to have significance in elementary particle physics, might explain the mystery of living matter and predict an entire hierarchy of new forms of matter.

As demonstrated in [L5], the notion of N-atom leads to an elegant model for the lock and key mechanism of bio-catalysis as well as the understanding of the DNA replication based on the spontaneous decay and completion of fermionic $N < N(G)$-particles to $N = N(G)$-particles. Optimal candidates for the N-particles are N-hydrogen atoms associated with bio-molecules appearing as letters in the "pieces of text" labelling the molecules. Lock and key would correspond to conjugate names in the sense that N_1 and N_2 for the letters in the name and its conjugate satisfy $N_1 + N_2 = N = N(G)$: as the molecules combine, a full fermion shell represented is formed.

6.3 Dark cyclotron states

Dark cyclotron states have been scaled spectrum $E_n = (n_a/n_b)E_n$ and for large values of n_a one can have energies above thermal threshold. The crucial observation is that the flux of ordinary magnetic field cannot divide into $N(G)$ dark fluxes since magnetic fluxes necessarily vanish at orbifold surfaces. Hence dark magnetic field would carry total flux which is $N(G)$ times higher than the flux of ordinary magnetic field of same intensity. Fermionic analogs of Bose-Einstein condensates are possible so that each cyclotron energy $E_n = n\hbar_0\omega$ would be replaced with spectrum extending from $(n_a/n_b)E_n$ to $(n_a/n_b)N(G_b)E_n$ in the case of fractionization.

6.4 Could q-Laguerre equation relate to the claimed fractionation of the principal quantum number for hydrogen atom?

In [F10] a semiclassical model based on dark matter and hierarchy of Planck constants is developed for the fractionized principal quantum number n claimed by Mills [82] to have at least the values $n = 1/k$, $k = 2, 3, 4, 5, 6, 7, 10$. This model can explain the claimed fractionization of the principal quantum number n for hydrogen atom [82] in terms of single electron transitions for all cases. The original model could not cope with $n = 1/2$: the basic reason is that Jones inclusions are characterized by quantum phases $q = exp(i\pi/n)$, $n > 2$. Since quantum deformation of the standard quantum mechanism is involved, this motivated an attempt to understand the claimed fractionization in terms of q-analog of hydrogen atom. The safest interpretation for them would be as states which can exist in ordinary imbedding space (and also in other branches). The natural guess would be that they can occur as intermediate states in the phase transition changing $n_b/n_a = 1$ to $k = 2, 3, ...$

The Laguerre polynomials appearing in the solution of Schrödinger equation for hydrogen atom possess quantum variant, so called q-Laguerre polynomials [17], and one might hope that they would allow to realize this semiclassical picture at the level of solutions of appropriately modified Schrödinger equation and perhaps also resolve the difficulty associated with $n = 1/2$. Unfortunately, the polynomials discussed in [17] correspond to $0 < q \leq 1$ rather than complex values of $q = exp(i\pi/m)$ on circle and the extrapolation of the formulas for energy eigenvalues gives complex energies.

6.4.1 q-Laquerre equation for $q = exp(i\pi/m)$

The most obvious modification of the Laguerre equation for S-wave sates (which are the most interesting by semiclassical argument) in the complex case is based on the replacement

$$
\begin{aligned}
\partial_x &\rightarrow \frac{1}{2}(\partial_x^{q)} + \partial_x^{\overline{q})}) \\
\partial_x^{q)} f &= \frac{f(qx) - f(x)}{(q-1)x} \ , \\
q &= exp(i\pi/m)
\end{aligned}
\tag{4}
$$

to guarantee hermiticity. When applied to the Laguerre equation

$$
x\frac{d^2L_n}{dx^2} + (1-x)\frac{dL_n}{dx} = nL_n \ , \tag{5}
$$

and expanding L_n into Taylor series

$$
L_n(x) = \sum_{n\geq 0} l_n x^n \ , \tag{6}
$$

one obtains difference equation

$$
\begin{aligned}
a_{n+1}l_{n+1} &+ b_n l_n = 0 \ , \\
a_{n+1} &= \frac{1}{4R_1^2}\left[R_{2n+1} - R_{2n} + 2R_{n+1}R_1 + 3R_1)\right] + \frac{1}{2R_1}\left[R_{n+1} + R_1\right] \\
b_n &= \frac{R_n}{2R_1} - n^{q)} + \frac{1}{2} \ , \\
R_n &= 2cos\left[(n-1)\pi/m\right] - 2cos\left[n\pi/m\right] \ .
\end{aligned}
\tag{7}
$$

Here $n^{q)}$ is the fractionized principal quantum number determining the energy of the q-hydrogen atom. One cannot pose the difference equation on l_0 since this together with the absence of negative powers of x would imply the vanishing of the entire solution. This is natural since for first order difference equations lowest term in the series should be chosen freely.

6.4.2 Polynomial solutions of q-Laquerre equation

The condition that the solution reduces to a polynomial reads as

$$
b_n = 0 \tag{8}
$$

and gives

$$
n^{q)} = \frac{1}{2} + \frac{R_n}{2R_1} \ , \tag{9}
$$

For $n = 1$ one has $n^{q)} = 1$ so that the ground state energy is not affected. At the limit $N \rightarrow \infty$ one obtains $n^{q)} \rightarrow n$ so that spectrum reduces to that for hydrogen atom. The periodicity $R_{n+2Nk} =$

R_n reflects the corresponding periodicity of the difference equation which suggests that only the values $n \leq 2m-1$ belong to the spectrum. Spectrum is actually symmetric with respect to the middle point $[N/2]$ which suggests that only $n < [m/2]$ corresponds to the physical spectrum. An analogous phenomenon occurs for representations of quantum groups. When m increases the spectrum approaches integer valued spectrum and one has $n > 1$ so that no fractionization in the desired sense occurs for polynomial solutions.

6.4.3 Non-polynomial solutions of q-Laquerre equation

One might hope that non-polynomial solutions associated with some fractional values of $n^{q)}$ near to those claimed by Mills might be possible. Since the coefficients a_n and b_n are periodic, one can express the solution ansatz as

$$\begin{aligned} L_n(x) &= P_a^{2m)}(x)\sum_k a^k x^{2mk} = P_a^{2m)}(x)\frac{1}{1-ax^{2m}} \ , \\ P_a^{2m)}(x) &= \sum_{k=0}^{2m-1} l_k x^k \ , \\ a &= \frac{l_{2m}}{l_0} \ , \end{aligned} \tag{10}$$

This solution behaves as $1/x$ asymptotically but has pole at $x_\infty = (1/a)^{1/2m}$ for $a > 0$.

The expression for $l_{2m}/l_0 = a$ is

$$a = \prod_{k=1}^{2m} \frac{b_{2m-k}}{a_{2m-k+1}} \ . \tag{11}$$

This can be written more explicitly as

$$\begin{aligned} a &= (2R_1)^{2m}\prod_{k=1}^{2m} X_k \ , \\ X_k &= \frac{R_{2m-k} + (-2n^{q)}+1)R_1}{R_{4m-2k+1} - R_{4m-2k} + 4R_{2m-k+1}R_1 + 2R_1^2 + 3R_1} \ , \\ R_n &= 2cos\left[(n-1)\pi/m\right] - 2cos\left[n\pi/m\right] \ . \end{aligned} \tag{12}$$

This formula is a specialization of a more general formula for $n = 2m$ and resulting ratios l_n/l_0 can be used to construct $P_a^{2m)}$ with normalization $P_a^{2m)}(0) = 1$.

6.4.4 Results of numerical calculations

Numerical calculations demonstrate following.

1. For odd values of m one has $a < 0$ so that a a continuous spectrum of energies seems to result without any further conditions.

2. For even values of m a has a positive sign so that a pole results.

For even value of m it could happen that the polynomial $P_a^{2m)}(x)$ has a compensating zero at x_∞ so that the solution would become square integrable. The condition for reads explicitly

$$P_a^{2m)}\left((\frac{1}{a})^{\frac{1}{2m}}\right) = 0 . \tag{13}$$

If $P_a^{2m)}(x)$ has zeros there are hopes of finding energy eigen values satisfying the required conditions. Laguerre polynomials and also q-Laguerre polynomials must posses maximal number of real zeros by their orthogonality implied by the hermiticity of the difference equation defining them. This suggests that also $P_a^{2m)}(x)$ possesses them if a does not deviate too much from zero. Numerical calculations demonstrate that this is the case for $n^{q)} < 1$.

For ordinary Laguerre polynomials the naive estimate for the position of the most distant zero in the units used is larger than n but not too much so. The naive expectation is that L_{2m} has largest zero somewhat above $x = 2m$ and that same holds true a small deformation of L_{2m} considered now since the value of the parameter a is indeed very small for $n^{q)} < 1$. The ratio $x_\infty/2m$ is below .2 for $m \leq 10$ so that this argument gives good hopes about zeros of desired kind.

One can check directly whether x_∞ is near to zero for the experimentally suggested candidates for $n^{q)}$. The table below summarizes the results of numerical calculations.

1. The table gives the exact eigenvalues $1/n_{q)}$ with a 4-decimal accuracy and corresponding approximations $1/n^{q)}_{\simeq} = k$ for $k = 3, ..., 10$. For a given value of m only single eigenvalue $n^{q)} < 1$ exists. If the observed anomalous spectral lines correspond to single electron transitions, the values of m for them must be different. The value of m for which $n^{q)} \simeq 1/k$ approximation is optimal is given with boldface. The value of k increases as m increases. The lowest value of m allowing the desired kind of zero of $P^{2m)}$ is $m = 18$ and for $k \in \{3, 10\}$ the allowed values are in range $18, .., 38$.

2. $n^{q)} = 1/2$ does not appear as an approximate eigenvalue so that for even values of m quantum calculation produces same disappointing result as the classical argument. Below it will be however found that $n^{q)} = 1/2$ is a universal eigenvalue for odd values of m.

m	$1/n^{q)}_{\simeq}$	$1/n^{q)}$	m	$1/n^{q)}_{\simeq}$	$1/n^{q)}$
18	**3**	2.7568	30	8	7.5762
20	**4**	3.6748	**32**	**8**	8.3086
22	5	4.5103	**34**	**9**	9.0342
24	**5**	5.3062	**36**	**10**	9.7529
26	**6**	6.0781	38	10	10.4668
28	**7**	6.8330			

Table 1. The table gives the approximations $1/n^{q})_{\simeq} = 1/k$ and corresponding exact values $1/n^{q})$ in the range $k = 3, ..., 10$ for which $P_a^{2m)}(x_\infty)$ is nearest to zero. The corresponding values of $m = 2k$ vary in the range, $k = 18, ..., 38$. For odd values of m the value of the parameter a is negative so that there is no pole. Boldface marks for the best approximation by $1/n^{q)}_{\simeq} = k$.

6.4.5 How to obtain $n^{q)} = 1/2$ state?

For odd values of m the quantization recipe fails and physical intuition tells that there must be some manner to carry out quantization also now. The following observations give a hunch about be the desired condition.

1. For the representations of quantum groups only the first m spins are realized. This suggests that there should exist a symmetry relating the coefficients l_n and l_{n+m} and implying $n^{q)} = 1/2$ for odd values of m. This symmetry would remove also the double degeneracy associated with the almost integer eigenvalues of $n^{q)}$. Also other fractional states are expected on basis of physical intuition.

2. For $n^{q)} = 1/2$ the recursion formula for the coefficients l_n involves only the coefficients R_m.

3. The coefficients R_k have symmetries $R_k = R_{k+2m}$ and $R_{k+m} = -R_m$.

There is indeed this kind of symmetry. From the formula

$$\begin{aligned} \frac{l_n}{l_0} &= (2R_1)^n \prod_{k=1}^{n} X_k \ , \\ X_k &= \frac{R_{n-k} + (-2n^{q)} + 1)R_1}{[R_{2n-2k+1} - R_{n-2k} + 4R_{n-k+1}R_1 + 2R_1^2 + 3R_1} \end{aligned} \tag{14}$$

one finds that for $n^{q)} = 1/2$ the formula giving l_{n+m} in terms of l_n changes sign when n increases by one unit

$$\begin{aligned} A_{n+1} &= (-1)^m A_n \ , \\ A_n &= \prod_{k=1}^{m} \frac{b_{n+m-k}}{a_{n+m-k+1}} = \prod_{k=1}^{m} (2R_1)^m \prod_{k=1}^{m} X_{k+n} \ . \end{aligned} \tag{15}$$

The change of sign is essentially due to the symmetries $a_{n+m} = -a_n$ and $b_{n+m} = b_n$. This means that the action of translations on A_n in the space of indices n are represented by group Z_2.

This symmetry implies $a = l_{2m}/l_0 = -(l_m)(l_0)^2$ so that for $n^{q)} = 1/2$ the polynomial in question has a special form

$$\begin{aligned} P_a^{2m)} &= P_a^{m)}(1 - Ax^m) \ , \\ A &= A_0 \ . \end{aligned} \tag{16}$$

The relationship $a = -A^2$ implies that the solution reduces to a form containing the product of m^{th} (rather than $(2m)^{th}$) order polynomial with a geometric series in x^m (rather than x^{2m}):

$$L_{1/2}(x) = \frac{P_a^{m)}(x)}{1 + Ax^m} \ . \tag{17}$$

Hence the n first terms indeed determine the solution completely. For even values of m one obtains similar result for $n^{q)} = 1/2$ but now A is negative so that the solution is excluded. This result also motivates the hypothesis that for the counterparts of ordinary solutions of Laguerre equation sum (even m) or difference (odd m) of solutions corresponding to n and $2m - n$ must be formed to remove the non-physical degeneracy.

This argument does not exclude the possibility that there are also other fractional values of n allowing this kind of symmetry. The condition for symmetry would read as

$$\prod_{k=1}^{m}(R_k+\epsilon R_1) = \prod_{k=1}^{m}(R_k-\epsilon R_1) \ ,$$
$$\epsilon = (2n^{q)}-1 \ . \tag{18}$$

The condition states that the odd part of the polynomial in question vanishes. Both ϵ and $-\epsilon$ solutions so that $n^{q)}$ and $1-n^{q)}$ are solutions. If one requires that the condition holds true for all values of m then the comparison of constant terms in these polynomials allows to conclude that $\epsilon = 0$ is the only universal solution. Since ϵ is free parameter, it is clear that the m:th order polynomial in question has at most m solutions which could correspond to other fractionized eigenvalues expected to be present on basis of physical intuition.

This picture generalizes also to the case of even n so that also now solutions of the form of Eq. 17 are possible. In this case the condition is

$$\prod_{k=1}^{m}(R_k+\epsilon R_1) = -\prod_{k=1}^{m}(R_k-\epsilon R_1) \ . \tag{19}$$

Obviously $\epsilon = 0$ and thus $n = 1/2$ fails to be a solution to the eigenvalue equation in this case. Also now one has the spectral symmetry $n_{\pm} = 1/2 \pm \epsilon$.

The symmetry $R_n = (-1)^m R_{n+m-1} = (-1)^m R_{n-m-1} = (-1)^m R_{m-n+1}$ can be applied to show that the polynomials associated with ϵ and $-\epsilon$ contain both the terms $R_n - \epsilon$ and $R_n + \epsilon$ as factors except for odd m for $n = (m+1)/2$. Hence the values of n can be written for even values of m as

$$n^{q)}(n) = \frac{1}{2} \pm \frac{R_n}{2R_1} \ , \ n = 1, ..., \frac{m}{2} \ , \tag{20}$$

and for odd values of m as

$$n^{q)}_{\pm}(n) = \frac{1}{2} \pm \frac{R_n}{2R_1} \ , \ n = 1, ..., \frac{m+1}{2} - 1 \ ,$$
$$n^{q)} = 1/2 \ . \tag{21}$$

Plus sign obviously corresponds to the solutions which reduce to polynomials and to $n^{q)} \simeq n$ for large m. The explicit expression for $n^{q)}$ reads as

$$n^{q)}_{\pm}(n) = \frac{1}{2} \pm \frac{(sin^2(\pi(n-1)/2m) - sin^2(\pi n/2m))}{2sin^2(\pi/2m)} \ . \tag{22}$$

At the limit of large m one has

$$n^{q)}_{+}(n) \simeq n \ , \ n^{q)}_{-}(n) \simeq 1-n \ . \tag{23}$$

so that the fractionization $n \simeq 1/k$ claimed by Mills is not obtained at this limit. The minimum for $|n^{q)}|$ satisfies $|n^{q)}| < 1$ and its smallest value $|n^{q)}| = .7071$ corresponds to $m = 4$. Thus these zeros cannot correspond to $n^{q)} \simeq 1/k$ yielded by the numerical computation for even values of m based on the requirement that the zero of $P^{2m)}$ cancels the pole of the geometric series.

6.4.6 Some comments

Some closing comments are in order.

1. An open question is whether there are also zeros $|n^{q)}| > 1$ satisfying $P_a^{2m)}((1/a)^{1/2m}) = 0$ for even values of m.

2. The treatment above is not completely general since only s-waves are discussed. The generalization is however a rather trivial replacement $(1-x)d/dx \rightarrow (l+1-x)d/dx$ in the Laguerre equation to get associated Laguerre equation. This modifies only the formula for a_{n+1} in the recursion for l_n so that expression for $n^{q)}$, which depends on b_n:s only, is not affected. Also the product of numerators in the formula for the parameter $a = l_{2m}/l_0$ remains invariant so that the general spectrum has the spectral symmetry $n^{q)} \rightarrow 1 - n^{q)}$. The only change to the spectrum occurs for even values of m and is due to the dependence of $x_\infty = (1/a)^{1/2m}$ on l and can be understood in the semiclassical picture. It might happen that the value of l is modified to its q counterpart corresponding to q-Legendre functions.

3. The model could partially explain the findings of Mills and $n^{q)} \simeq 1/k$ for $k > 2$ also fixes the value of corresponding m to a very high degree so that one would have direct experimental contact with generalized imbedding space, spectrum of Planck constants, and dark matter. The fact that the fractionization is only approximately correct suggests that the states in question could be possible for all sectors of imbedding space appear as intermediate states into sectors in which the spectrum of hydrogen atom is scaled by $n_b/n_a = k = 2, 3, ...$

4. The obvious question is whether q-counterparts of angular momentum eigenstates ($idf_m/d\phi = mf_m$) are needed and whether they make sense. The basic idea of construction is that the phase transition changing $\hbar$ does not involve any other modifications except fractionization of angular momentum eigenvalues and momentum eigenvalues having purely geometric origin. One can however ask whether it is possible to identify q-plane waves as ordinary plane waves. Using the definition $L_z = 1/2(\partial_u^q + \partial_u^{\overline{q}})$, $u = exp(i\phi)$, one obtains $f_n = exp(in\phi)$ and eigenvalues as $n^{q)} = R_n/R_1 \rightarrow n$ for $m \rightarrow \infty$. Similar construction applies in the case of momentum components.

7 Dark matter, long ranged weak force, condensed matter, and chemistry

The challenge of understanding the effects of dark weak force in condensed matter and chemistry is not easy since so many options are available. The guidelines to be used are maximal conservatism, nuclear string model and model for the cold fusion, the general criterion for the transition to dark phase, and intriguing hints that dark weak force could play important role not only in biochemistry but also in ordinary condensed matter physics contrasted with the fact that isotopic independence is not visible in the physics of condensed matter and in chemistry.

7.1 What is the most conservative option explaining chiral selection?

Long ranged exotic weak interactions should produce parity breaking responsible for the chiral selection. The first thing that comes in mind is that ordinary quarks or nucleons suffer a phase transition in which the p-adic prime characterizing weak space-time sheets increases, perhaps to one of the Gaussian Mersennes $k = 113, 151, ...$

There are objections against this idea.

1. The criterion $\alpha_w Q_1 Q_2 \simeq 1$ for the transition to dark phase does not apply at weak space-time sheets so that ordinary quarks should not perform this transition.

2. If ordinary nucleons make the transition to the dark weak phase with $k \leq 113$, very strong Z^0 Coulombic interaction results and isotopic dependence of chiral symmetry breaking is predicted.

3. Repulsive weak interaction would provide a nice explanation for the hard core of the interaction potential in van der Waals equation for liquid phase. Isotopic dependence is again the problem.

Nuclear string model [F9] suggests a maximally conservative model for chiral selection consistent with these objections.

1. Assume that nucleons are not affected at all in the transition and that nothing happens in the transition even at the level of exotic quarks so that they must have weak space-time sheets with size at least of order atom size.

2. The weak space-time sheet of exotic quarks associated with $k = 127$ color bonds cannot correspond to $k = 89$ since this would be seen in the decay width of the ordinary electro-weak gauge bosons. The model of cold fusion requires a phase transition transforming D to its neutral variants and this phase transition can only occur via the exchange of exotic W bosons with the range of weak interactions of order atomic distance (at least). Dark variants of $k = 113$ W bosons with $n = 2^{11}$ defines one option.

3. It would be nice to have weakly charged nuclei. Weak charges should not be however too large. This is achieved if some of the color bonds containing exotic quark and anti-quark at their ends carry net em charge and thus also weak charge. This hypothesis allows to understand tetra-neutron as an alpha particle containing two negatively charged color bonds and predicts entire spectroscopy of exotic nuclei containing charged color bonds [F8, F9]. Cold fusion could be understood in terms of absence of Coulomb wall in the collision of ordinary proton with neutral variant of deuteron [F9].

4. Instead of ordinary neutrinos transformed to dark neutrinos in weak sense, neutrino species associated with with weak space-time sheets would be present and participate in the weak screening together with exotic W^+ bosons and possible exotic counterparts of electrons. The Gaussian Mersennes associated with $k = 151, 157, 163, 167$ define good candidates for the space-time sheets of exotic leptons. There is experimental evidence that neutrinos appear in several mass scales [F3].

5. Also higher levels of darkness would be allowed by the standard criterion applied to say molecules. Also a hierarchy of colored dark matters could emerge as nuclei get net color charge and combine to form molecules which are color singlets.

Consider now the implications of this picture.

1. The repulsive weak interaction between exotic of quarks of color bonds with net em and weak charge could explain the hard core of the interaction potential in van der Waals equation without isotope dependence.

2. Bio-control could occur by the variation of weak screening using W^+ bosons and exotic neutrinos. The resulting parity breaking effects would be large below the length scale L_w. Chiral selection would not have isotope dependence.

7.2 Questions related to ordinary condensed matter and chemistry

Consider first some questions related to ordinary condensed matter and chemistry.

1. Could electromagnetic darkness relate to the properties condensed matter?

The purely electromagnetic dark phase for $k = 113$ space-time sheets without dark weak bosons implies that atomic nuclei possess field bodies of atomic size, and one can wonder how this might relate to the basic properties of condensed matter. For instance, the linking of magnetic flux tubes of field bodies of different nuclei might have some role in quantum information processing, if the general vision of [E9] about topological quantum computation in terms of linking of magnetic flux tubes is taken seriously.

2. Does repulsive weak force relate to the stability of condensed matter?

The Coulomb repulsion of electrons could be enough to explain van der Waals equation of state. One can still wonder whether the dark weak force effective below the length scale $L_w(dark)$ could have something to do with the repulsive core in van der Waals equation of state and with the sizes of atoms in condensed matter.

The low compressibility of condensed matter indeed suggests that repulsive Z^0 force between constituent molecules is present or at least appears when one tries to compress condensed matter. The long ranged weak interactions between exotic quarks associated with color bonds of condensed matter nuclei would explain this without predicting non-trivial isotopic effects in van der Waals equation. The most conservative option is that compression induces a phase transition to a phase in which nuclei contain charged color bonds and generates strong Z^0 repulsion in the length scale of atomic radius. The fact that the density of water is reduced above freezing point when pressure is increased or temperature reduced might have explanation in terms of this mechanism.

The orthodox physicist would presumably argue that the mere electromagnetic interactions allow to understand the value of the atomic radius. The following argument challenges this belief in the case of heavy atoms.

The size of atom in the absence of the classical dark weak forces can be estimated from the expression of the radius of the orbital n given by $r_n = n^2 a$, where $a = a_0/Z$ is the radius of the lowest electronic orbital, and from the fact that a given orbital contains $2n^2$ electrons. In a reasonable approximation one has $Z = 2n_{max}^3/3$ and $n_{max} = (3Z/2)^{1/3}$. In this approximation the radius of the largest orbital identifiable as the atomic radius r_Z is

$$r_Z = (\frac{3}{2})^{2/3}\frac{a_0}{Z^{1/3}} \quad . \tag{24}$$

Indeed, at distances above this radius the atom looks more or less neutral since electrons screen the nuclear charge completely. This gives an estimate for the density of the condensed phase consisting of atoms with nuclear charge Z.

$$\rho = \frac{4}{9}AZ \times \frac{m_p}{a_0^3} \quad . \tag{25}$$

In case of iron ($A = 55, Z = 26$) one would have $\rho \simeq 635$ kg/dm^3: the value is roughly 100 times higher actual value $\rho = 7.8$ kg/m^3 at room temperature!

Thus the radii of heavy atoms seem to be too large in the standard physics framework. The transition to a phase in which charged color bonds are present is expected to be especially probable in the case of heavy nuclei and a generation of repulsive Z^0 force might explain the radii.

3. Could the repulsive weak core relate to the stability of chemical compounds?

Could the long ranged repulsive weak force relate the typical lengths of chemical bonds? Could it even make possible valence quark approximation? Since the generation of weakly charged color bonds and even color bonds connecting different atomic nuclei does not involve isotopic dependence, one must consider the possibility that these forces might be involved even with the physics of chemical bonds.

For instance, the generation of a chemical bond might involve formation of state containing a component in which the two nuclei have generated color bonds with opposite charges creating additional attractive force. One can also consider the possibility that nuclei generate anomalous electromagnetic charge of same sign so that a repulsive weak force between atoms results. This would give rise to a hard sphere behavior essential for the notion of valence.

At least at classical level one can question the hard sphere behavior of atoms assumed implicitly in the models of molecules based on molecular orbitals and allowing to treat full electronic shells as rigid structures so that only valence electrons are dynamical and give rise to shared orbitals. One can argue that purely electromagnetic atoms/molecules do not behave like hard spheres and that all electrons should be treated like valence electrons moving in the combined Coulomb field of the two nuclei whose distance is not fixed by the molecular size.

Since electrons are very light, one could classically regard the electronic cloud as a perfectly conducting rapidly deformable shell. When atoms approach each other the electronic charge density arranges in such a manner that it minimizes the Coulombic interaction energy between nuclei by preventing the penetration of the nuclear electric field of the other atom through the electronic shell. There the encounter of atoms would be more like a collision of point nuclei surrounded by highly deformable smooth electron mattresses than that of hard spheres.

What could go wrong with this argument? Fermi statistic might change the situation and make closed electronic shells to behave like rigid charged spheres.

7.3 Dark-to-visible phase transition as a general mechanism of bio-control

Dark-to-visible phase transition reduces the de-Broglie wave lengths by a factor $1/n = 2^{-11}/k$ for the favored value of the scaling factor of $\hbar$ (also other values of scaling factor are of course possible). This would essentially code patterns in dark length scale to patterns of visible matter in much shorter length scale and make possible long length scales to control short length scales in a coherent manner. This phase transition could occur separately on em, weak, and color space-time sheets. For instance, the dark phase of hydrogen ions in the case of proton need not involve dark weak phase.

The hierarchy of dark matters defines naturally a control hierarchy ordered with respect to time and length scales. Dark electrons would be functional at the lowest level of the control hierarchy whereas dark neutrinos would naturally appear at the higher levels.

The strange properties of water could be understood to a great extent if a fraction of protons has made a transition large $\hbar$ phase in electromagnetic sector (as discussed, this could actually mean that the em bodies of protons have large $\hbar$). This does not require anything anomalous in the weak and colored sectors.

The criterion for the transition is that a system consisting of sub-systems with charges Z_1 and Z_2 makes a transition to dark matter phase reads as $\alpha_{em} Z_1 Z_2 \simeq 1$.

Option I: If this criterion applies to self interactions as such, it would give in the case of atomic nuclei $Z_{cr} = 12$ (Mg).

Option II: If full nuclear shells are non-interacting, as one expects on basis of Fermi statistics, the criterion could be interpreted as stating that only nuclei having $Z = 2 + 6 + 12 = 20$ (the self interaction of the full third shell would induce the transition) can make this transition [F8]. That Ca ions ($Z = 20$) satisfy this condition would conform with the fact that play a unique role in bio-chemistry and neurophysiology.

Option III: If the criterion does not apply to self interactions and only full shells interact, the condition would be that the nucleus contains nucleon clusters with charge $Z_1 = Z_2 = 20$ giving $Z_{cr} = 40$ if the critical interaction is between separate $Z = 12$ shells. TGD inspired view about nuclear physics [F8] based on dark valence quarks and $k = 127$ exotic quarks with ordinary value of $\hbar$ at the ends of long color bonds responsible for nuclear strong force suggests that nuclei could be regarded as collections of linked and knotted nuclear strings and that the linking of magic nuclei produces new especially stable nuclei.

Cold fusion with Pd catalyst [64] having $Z = 46$ could involve local transitions of Pd catalyst to $k = 113$ dark matter phase and perhaps also the transition $k = 89 \rightarrow 113$.

For option III trace elements with $Z \geq 40$ should play a key role in living matter inducing phase transitions of lighter nuclei to dark phase as the model for cold fusion suggests. There is some support for this interpretation.

1. DNA is insulator but the implantation of Rh atoms in DNA strands is known to make it super-conductor [93], perhaps even super-conductor. Dark electrons obviously define a good candidate for the current carriers.

2. The so called mono-atomic elements [85] claimed by Hudson to possess very special physical properties have explanation in terms of dark matter phase transition [J6] and have $Z \geq 44$. Interestingly, Hudson claims that mono-atomic elements have not only very special biological effects but also affect consciousness, and that 5 per cent of brain tissue of pig by dry matter weight is Rhodium ($Z = 45$) and Iridium ($Z = 77$).

7.4 Long ranged weak forces in chemistry and condensed matter physics

According to the model of water, one fourth of hydrogen ions would be in dark phase such that $k = 113$ space-time sheet has transformed to large $\hbar$ phase and would have size of order atomic radius. This would suggests that that the atomic size could be understood in terms of large $\hbar$ associated with $k = 113$ electromagnetic space-time sheet. Weak interactions in this phase could be normal. Quantum classical correspondence forces however to consider the possibility for which also long range weak force is present-

7.4.1 Exotic nuclear quarks as sources of long ranged weak force

One can a consider a copy of weak physics for which weak space-time sheets of particles have $k > 89$, say $k = 113$. This would imply strong parity breaking effects in $k = 113$ length scale. If this transition is followed by a transition of $k = 113$ space-time sheet to dark matter phase with large value of $\hbar$, the length scale $L_w(dark) = n2^{11}L(113)$ in which strong parity breaking effects occur corresponds to atomic length scale. This kind of phase could explain chiral selection in living matter and dark weak boson condensates and dark quarks and leptons might play a fundamental role in bio-control.

The criterion for the transition to the large $\hbar$ phase does not suggest that this transition could happen to ordinary quarks and leptons. Also the fact the absence of non-trivial isotopic dependence in chemistry and condensed matter supports the conservative view "once vacuum screened-always vacuum screened".

The TGD based model of atomic nuclei however involves besides dark valence quarks color bonds having $k = 127$ quarks at their ends and their weak space-time sheets cannot correspond to $k = 89$ since this would be reflected in the decay widths of weak bosons. One possibility is that the weak space-time sheet corresponds to $k = 113$, possibly with large $\hbar$.

TGD based identification of tetra-neutron is as an alpha particle containing two negatively charged color bonds [F8]. Since there is no reason to expect that tetra-neutron would be a rare exception, one expects that ordinary nuclei of condensed matter can make transition to a phase in which some color bonds are em charged and thus carry also weak charges creating long ranged weak forces and parity breaking without the un-acceptable isotopic independence. The unavoidable long ranged weak and color fields associated with non-vacuum extremals suggest even more radical possibility. The nuclear strings associated with neighboring condensed matter nuclei could fuse to single nuclear string so that nuclei would be color and weakly charged and could carry fractional em charges.

Below $L_w(dark)$ atoms whose nuclear color bonds carry net weak charges would look like Z^0 ions and condensed matter in this phase would be kind of Z^0 plasma. The weak forces could be screened by vacuum charges above the length scale $L_w(dark)$ just as they are screened usually. Dark weak bosons would have mass obtained by scaling down the intermediate gauge boson masses by a factor 2^{-12} for $k = 113$. An essential point is that the Z^0 charge density of nuclei would be constant below L_w rather than that corresponding to Z^0 charges with nuclear size. This makes Z^0 screening by particles much more easier and the question is not whether to achieve precise enough screening in say nuclear length scale but in what scale it is possible to vary the degree of screening.

7.4.2 Could long ranged weak forces be key players in bio-catalysis?

Bio-catalysis involves chiral selection in an essential manner which suggests that weak force is involved. This inspires the question about the underlying mechanisms controlling the assembly and de-assembly of bio-molecules.

1. Bio-catalysis and phase transition to a phase containing charged color bonds?

The considerations related to van der Waals equation and the fact that color bonds could be unstable against beta decay via the emission of light W boson nucleon suggest that nuclei could tend to develop color bonds with the same sign of Z^0 charges. Anomalous em charges could vanish if the transition involves an emission of a dark W boson charging color bond transforming to ordinary weak boson by de-coherence and absorbed by nucleon. This kind of transition could proceed spontaneously as a two-nucleon process if the nuclei are close enough as in the situation when liquid is compressed.

If so, the resulting weak forces tend to de-stabilize these molecules. The range $L_w \simeq 2.56L(89)$ gives for this force a scale about $2.56 \times L(k_{eff} = 133) \simeq 1.3n$ Angstrom if scaled directly from the Compton length of intermediate gauge boson assuming the scaling $\hbar \rightarrow n\hbar/v_0$. $n = 3$ gives the length scale of the typical chemical bond in DNA.

The molecules need not become un-stable in the phase transition to the phase containing charged color bonds. The phase transition could only reduce the binding energies of the chemical bonds and facilitate chemical reactions serving thus as a catalyst.

Dark molecules of form AH_n, where A is arbitrary atom and H_n refers to n hydrogen atoms be in the role of biological hardware since they are not affected appreciably by this kind of phase transition. The basic molecules of life are indeed molecules of type CH_n, OH_n, NH_n, which could of course be also partially dark.

2. The variation of the strength of the Z^0 force as a control mechanism

The variation of the strength of the repulsive Z^0 force could be achieved by varying the density of screening particles. To be effective this tool should allow sharp enough length scale resolution and the resolution is determined by the p-adic length scale of the screening particle. The situation is dramatically improved by the fact that the Z^0 charge density to be screened is constant below L_w. Hence a constant Z^0 charge density of screening charges is enough to achieve a complete screening. The control of the degree of Z^0 ionization rather than control of Z^0 charge density would be in question.

3. What distinguishes between ordinary condensed matter and living matter?

If weakly charged color bonds appear already in ordinary condensed matter and give rise to the repulsive core in van der Waals equation of state, one can wonder what is the real distinction between living matter and ordinary condensed matter. The difference might relate to the value of n for the transition $\hbar \rightarrow n\hbar/v_0$ for electromagnetic space-time sheets. $n = 1$ could correspond to ordinary condensed matter with L_w in the range of 1-2 Angstrom and $n = 3$ to living matter with L_w in the range 3-6 Angstrom. Water could differ from other condensed matter systems in that it would have $n = 3$ for one fourth of hydrogen ions.

A second question relates to the identification of the weak space-time sheet of exotic quarks. Can one assume that the weak space-times sheet of exotic quarks and em space-time sheet of valence quarks in dark em phase both correspond to $k = 113$ with large $\hbar$? This hypothesis can be defended: below L_w dark electro-weak symmetry is not broken so that em and weak interactions should take place at the same space-time sheet.

7.5 Z^0 force and van der Waals equation of state for condensed matter

Most physicists probably think that van der Waals equation of state represents those aspects of condensed matter physics which have been thoroughly understood for long time ago. Approximate isotopic independence of the basic parameters of the state equation provides support for this belief. Isotopic independence does not however exclude the role of long ranged weak forces if they are associated with exotic $k = 127$ quarks appearing in the TGD based model of nucleus [F8]. The decay widths of weak bosons require that exotic weak bosons correspond to some other p-adic length scale than $k = 89$, say $k_{eff} = 113 + 24 = 137$ for large $\hbar$ or $k = 151$ for ordinary $\hbar$. The presence of em charged color bonds in ordinary nuclei would provide them with anomalous em and weak charges and bring in long ranged weak force.

One can imagine various scenarios for how dark weak forces might enter condensed matter physics.

1. It might be energetically favorable for the ordinary condensed matter nuclei to be in a phase containing charged color bonds. By the charge independence of strong interactions this would not considerably affect the nuclear physical properties of condensed matter nuclei. The hard core of the interaction potential in van der Waals equation could be seen as a signature of dark weak force.

2. The nuclei could be ordinary in the ordinary liquid phase (water forming a possible exception) so that long ranged weak forces need not be present. The low compressibility of the liquid phase could however be due to a phase transition of nuclei inducing charged color bonds by exotic weak decays of exotic quarks. This would induce a repulsive weak force felt in the length scale L_w of order $3 - 6$ Angstrom for $k = 113$ and $\hbar \rightarrow n\hbar/v_0$, $n = 3$. The dark weak force becoming visible only when liquid is compressed would explain the hard core term in van der Waals equation. The energy provided by the compression would feed in the energy making possible the phase transition not occurring spontaneously. Sono-luminescence [80] could represent a situation in which the phase transition occurs.

   The phase transition generating charged color bonds could be induced by the direct contact of the nuclear em field bodies of exotic quarks and anti-quarks with size associated with any nucleus having $A > 1$ and having field em field body with size $L \sim nL(113)/v_0$ of order atomic radius (this point is discussed in detail in the model of nuclei based on color bonds [F8]).

Both options predict isotopic independence of compressibility and essentially standard nuclear physics. The explanation for the anomalous behavior of water above its freezing point, in particular the reduction of density as the temperature is lowered or pressure increases, could be basically due to the appearance of additional color bonds in oxygen nuclei during compression.

These considerations raise the question how weak forces reveal their implicit presence in the basic argumentation leading to van der Waals equation of state. In the sequel the deduction of van der Waals discussed in more detail to make more explicit the origin of the hard core term.

1. Van der Waals equation of state

Van der Waals equation of state provides the simplest thermodynamical model for gas-liquid phase transition. The equation can be derived from thermodynamics using the following assumptions.

1. The partition function Z_N for a condensed matter system consisting of N identical particles codes the thermodynamical information and can be deduced once the Hamiltonian of the system is known.

2. It is assumed that the Hamiltonian separates into a sum of single particle Hamiltonians $H = \sum H_i = T + U = \sum T_i + \sum U_i$. Single particle Hamiltonian consists of a sum of the kinetic energy T_i, the energy associated with internal degrees of freedom (such as rotational degrees of freedom of the molecule), and the potential energy $U_i = \sum_{j\neq i} u_{ij}$.

3. The potential energy u_{ij} is assumed to depend on the relative coordinate $\overline{r}_i - \overline{r}_j$ only and to be large and positive at short distances and vanish rapidly at large distances. Also spherical symmetry can be assumed in a good approximation. Above $2r_0$, r_0 molecular radius, u is assumed to be small and negative and in this manner generate an attractive force, which can be assumed to be of electromagnetic origin.

Consider now the approximate deduction of the equation of state.

1. The partition function factors into a product of the partition function Z_N^{id} of ideal gas and a term defined by the potential energy terms in the Hamiltonian of the whole system.

$$\begin{aligned} Z &= Z_N^{id}(T) \times Q_N(T,V) \ , \\ Q_N(T,V) &= \frac{1}{V^N}\int \prod_i dV_i exp(-U/T) \ . \end{aligned} \tag{26}$$

2. The standard manner to derive an approximate form of the partition function, free energy and pressure in turn providing the equation of state is based on the so called virial expansion using the elementary multiplicative properties of the exponential function $exp(-U/T) = \prod_{i,j} exp(-u_{ij}/T)$ appearing in Q_N. In the lowest non-trivial order one has

$$\begin{aligned} Q_N(T,V) &\simeq \frac{N^2}{V} I_2 \ , \\ I_2 &= \int dV \lambda(\overline{r}) \ , \\ \lambda(\overline{r}) &= exp(-u_{12}(\overline{r})/T) - 1 \ . \end{aligned} \tag{27}$$

The integrand in this expression is in a good approximation equal to -1 inside the sphere of radius $2r_0$ defined by the minimal distance between the molecules of radius r_0 and positive outside this sphere and approaches zero rapidly.

3. Quite generally, one can write Q_N as

$$
\begin{aligned}
Q_N(T,V) &\simeq 1 + N \times \frac{n}{2} \times I_2 \simeq (1 + \frac{nI_2}{2})^N \quad , \\
n &= \frac{N}{V} \quad .
\end{aligned} \tag{28}
$$

The improved approximation is dictated by the fact that free energy must be an extensive quantity. For the free energy $F = -Tln(Z)$ one obtains an approximate expression

$$
F = NF^{id} - NTnI_2 \quad . \tag{29}
$$

For the pressure $P = -(\partial F/\partial V)_{T,N}$ one obtains

$$
P = nT(1 - nI_2/2 + \cdots) \quad . \tag{30}
$$

4. The value of I_2 can be calculated approximately by dividing the integration region to two parts. The first part corresponds to a sphere of radius $2r_0$ (r_0 is the radius of molecule) inside which $\lambda_{12} = -1$ could be interpreted in terms of the approximate vanishing of the exponential of the interaction potential behaving like $1/r$. The second part corresponds to the exterior of the sphere of radius $2r_0$, where λ is assumed to have positive but small values so that the exponential can be approximated by the first two terms of the Taylor series with respect to u_{12} This gives

$$
I_2 \simeq \quad -\tfrac{4\pi}{3}(2r_0)^3 + \tfrac{4\pi}{T}\int drr^2 u_{12}(r) \equiv 2b - 2a/T \quad . \tag{31}
$$

Note that $a > 0$ implied by $u_{12} \leq 0$ holds true.

5. The resulting equation of state is

$$
P + n^2 a = nT(1 + nb) \quad . \tag{32}
$$

This equation is second order in n and does not give the characteristic cusp catastrophe associated with the van der Waals equation.

6. The approximation

$$
1 + nb \simeq \frac{1}{1 - nb} \tag{33}
$$

holding true for $nb << 1$ and then extrapolating to a region where this condition does not hold true. This gives the van der Waals equation of state

$$
(P + n^2 a)(1 - nb) = nT \tag{34}
$$

allowing a simple description of gas-to liquid phase transition requiring that at least third power of n appears in the equation of state. The equation allows an attractive physical interpretation. $P_{in} \equiv n^2 a$ can be identified as internal pressure mainly due to the attractive van der Waals force and 1-nb tells the fraction of free volume so that $P_{tot}V_{free} = NT$ holds true.

This trick is believed to take into account the neglected higher order terms in the virial expansion. The proper justification comes from the catastrophe theory [18]. The virial expansion gives all orders in n to the right hand side of Eq. 32 and by the general theorems of catastrophe theory cusp catastrophe is the singularity associated with a state equation with two control variables a and b. What the cusp catastrophe means is that three values of n satisfy the equation of state for given values of P and T. Two of these values correspond to stable phases, liquid and gas, the lower and upper sheets of the cusp, whereas the intermediate sheet of the cusp corresponds to an unstable phase.

In TGD framework a could be interpreted as characterizing purely electromagnetic interactions above the critical radius r_0 and and b both em and long ranged interactions below r_0. The emergence of repulsive Z^0 interactions below the critical radius r_0 would serve as a physical definition for r_0. The fraction of free volume $1 - nb$ would differ from unity because repulsive dark weak forces enter in play when the number density n tends to become larger than $1/b$.

In a very optimistic mood one might provocatively claim that the classical Z^0 Coulombic force allows to understand why the hard core approximation behind van der Waals equation works and that the setting on of dark weak force provides a precise first principle definition for the notion of the molecular radius. The criticality implied by the Z^0 Coulombic force would reflect itself as the criticality of the liquid-gas phase transition. Obviously the parameter b contains very little information about the details of the Z^0 Coulombic interaction energy besides the fact that the phase transition charging some color bonds weakly occurs when molecules are at distance $r < r_0$. The calculation of the value of the parameter a should reduce to standard electromagnetic interactions between molecules.

7.6 Z^0 force and chemical evolution

Although long ranged weak forces manages to hide themselves very effectively, they leave some tell tale traces about its presence. The most spectacular effect is chiral selection which is extremely difficult to understand in the standard model. Also the mysterious ability of noble gases to act as anesthetes [86] could be understood as being due to dark weak forces. If a phase transition charging some color bonds of the noble gas nuclei increasing or reducing Z occurs, noble gas atoms behave chemically as ions. A discussion (somewhat obsolete now) of the mechanism can be found in [M2].

Classical Z^0 force might also make itself visible by delicate chemical effects due to the fact that the classical Z^0 charge of the hydrogen atom vanishes. Since the exotic Z^0 charges of proton and electron necessarily vanish by the absence of color bonds the prediction is that proton and electron are in a completely exceptional role in chemistry, and in biochemistry in particular. Certainly this is the case: consider only the role of proton and electron in biochemistry (say in metabolic cycles and in polymerization). Furthermore, Z^0 force seems to be the key player in the biochemical evolution in TGD Universe: molecular stability could be controlled by the possibility to generate charged color bonds and by the screening of long ranged weak forces.

Enzymatic action, known to involve chiral selection, can be based on the control of the strength of the classical Z^0 force by varying the densities of the Bose-Einstein condensates responsible for the Z^0 screening. Metabolism involves basically the chopping of the nutrient molecules to pieces and their re-assembly. The chopping into pieces could be partially achieved by weakening the screening of the classical Z^0 force locally. The sizes of the enzymes and ribozymes are rather large and vary in the range 10-20 nm. This is not easily understood in the standard chemistry context but is what one expects if $k = 151$ weak bosons are involved.

An interesting hypothesis is that chemical evolution has proceeded via a sequence of phase transitions producing dark weak bosons corresponding to Gaussian Mersennes $G_k = (1+i)^k - 1$, $k = 113, 151, ...$ as $k = 89 \rightarrow 113$ followed by $k = 113 \rightarrow 151 \rightarrow 157 \rightarrow 163 \rightarrow 167 \rightarrow ....$

7.7 Parity breaking effects at molecular level

The observed parity breaking effects at molecular level are large: a natural unit for molecular dipole moments is one Debye: $e10^{-10}$ $m \sim eL(137)$. This scale compares favorably with the $k = 113$ weak length scale $L_w = nx$ Angstrom, $x \in [1, 2]$, $n = 1, 2, 3$. The larger the value of n, the larger the scale of parity breaking. The breaking of the mirror symmetry appears at geometric level and this kind of symmetry breaking does not require large parity breaking at the level of physics laws. The parity breaking however takes place in a much deeper manner: only second chirality of two mirror image molecules appears in Nature and an unsolved problem is to understand this selection of the molecular chirality.

The axial part of weak forces, in particular Z^0 force, suggests a first principle explanation for the molecular parity breaking. A phase transition generating dark weak force below length scale L_w would induce axial force implying different energies for mirror images of molecule.

7.7.1 Mechanism of parity breaking

One can imagine two mechanisms of chiral selection. For the first mechanism the classical Z^0 interactions between the atoms of the molecule lead to a chiral selection. If equilibrium positions correspond to the minima of Z^0 Coulomb energy, the parity breaking effect, being proportional to the gradient of Z^0 scalar potential, however vanishes. Of course, the net force involves both electromagnetic and Z^0 contributions so that the equilibrium positions do not actually correspond to the minima of Z^0 Coulomb potential. Proton is an exception because of its small vectorial Z^0 charge and by the fact that it is the only nucleus not containing color bonds (assuming that self bonding does not occur).

Second mechanism is based on the presence of an external Z^0 electric field and to the fact that the energies of a chiral molecule and its mirror image in an external Z^0 electric field are different. In this case the parity breaking contributions of the individual atoms of the molecule to the energy are in general non-vanishing and lead to chiral selection. The presence of classical Z^0 electric fields in bio-matter would not be surprising since bio-matter is also ordinary electret. Spontaneous Z^0 electric polarization might be an essential element of chiral selection and lead to energy minimization. This kind of phase transition might be induced by a rather small external perturbation such as bombarding of a system containing both chiralities with neutrinos or electrons.

7.7.2 Detailed form of the parity breaking interaction

Consider first in more detail the form of parity breaking interaction.

1. In molecular physics the minimization of the energy for electronic configurations selects the ground state configuration for atoms in the molecule (this is essentially due to the small mass ratio m_e/m_p).

2. The parity breaking force is proportional to the axial part of weak isospin, which is of same magnitude for all particles involved. Axial force is proportional to the gradient of Z^0 scalar potential created by exotic quarks in color bonds. Axial force is also inversely proportional to the mass of the particle involved.

The mass scale of exotic quarks is determined by $k = 127$. The hypothesis that lepto-hadrons are bound states of colored excitations of leptons predicts also $k = 127$ for their mass scale and colored electrons would have essentially the same mass as electrons. One can make only guesses about the p-adic mass scale of exotic (possibly dark) neutrinos and electrons. The maximally non-imaginative hypothesis is that the scales are same as for ordinary leptons. In this case the mass would by a factor of about 10^{-6} smaller for dark $k = 169$ neutrinos with mass about .1 eV than for exotic quarks with mass $\sim .1$ MeV if p-adically scaled down from that of ordinary quarks [F8]. Therefore the presence of dark neutrinos could induce the dominating parity breaking effects. For this option the Z^0 binding energy would be much larger than neutrino mass for reasonable values of nuclear Z^0 charge, which would favor the Z^0 screening by neutrinos.

3. The parity breaking Z^0 interaction energies of exotic $k = 127$ quark and anti-quark at the ends of color bond are of same sign in three cases corresponding to pion type color singlet bonds $q^{\uparrow}\overline{q}^{\downarrow}$ and em and color charged bonds $u^{\uparrow}\overline{d}^{\uparrow}$ and $d^{\uparrow}\overline{u}^{\uparrow}$. Thus the parity breaking interaction does not require the presence of color charged bonds and is in principle present for all nuclei but can of course cancel in good approximation if the net spins of $k = 127$ quarks and anti-quarks do not cancel separately.

4. For Fermi sea of dark neutrinos the parity breaking effects on energy are proportional to spin and sum up to zero if the number of neutrinos is even. Note however that complete screening is not required.

Consider now a more quantitative estimate.

1. The axial part of the Z^0 force acting on neutrinos is given by

$$V_{NPC} \simeq \pm \alpha_Z Q_Z^A(\nu) Q_Z^V(\nu) \frac{1}{m(\nu)} \bar{S} \cdot \nabla V_Z(\bar{r}) \ . \tag{35}$$

2. The order of magnitude for the energy difference of a configuration and its mirror image is obtained as the difference of axial interaction energies for configurations related by reflection. Consider a particle with Z^0 charge $Q_{Z,1}$ and mass m experiencing the axial Z^0 field created by a nucleus with anomalous Z^0 charge $Q_{Z,2}$. In this case the contribution to energy difference has order of magnitude

$$|\Delta E| \sim \frac{\alpha_Z (Q_{Z,1} Q_{Z,2}}{4mL^2} \ , \tag{36}$$

where $L \leq L_w$ is the typical distance between nucleus and the particle involved.

3. Consider now various options for the parity breaking assuming first $k = 113$ dark weak matter so that L is of order of size of atom.

i) For $k = 169$ neutrino one would have $\Delta E \sim 1$ MeV, which does not sound reasonable. If partial neutrino screening is present for $k = 113$ at all, it must involve spin pairing. As already found, neutrino screening cannot be ideal for $k = 113$ since the Fermi energy would be rather high. Partial screening favored by the negative energies of dark neutrinos cannot be however excluded since single neutrino could be shared between several constituents of, say, linear molecule. For $k = 151$ for neutrino and electron one would have $\Delta E \sim 2$ keV.

ii) For an exotic electron with ordinary mass but $k = 113$ weak space-time sheet the order of magnitude is $\Delta E \sim 2$ eV, which corresponds to visible frequencies. For exotic quarks with mass $m \sim .1$ MeV one would have $\Delta E \sim 10$ eV. For both cases it would not be chiral selection which would thermally unstable but the dark weak phase itself, and the selection would be absolute in the temperature range were dark weak phase is possible.

iv) For dark $W^+(113)$ bosons having mass ~ 25 MeV one would have $\Delta E \sim 10^{-2}$ eV, which corresponds to the scale of room temperature. Unfortunately, the large mass and short lifetime of $W^+(113)$ do not favor this idea.

4. Consider now $k = 151$ weak bosons. The difficulties of $W^+(113)$ option are circumvented in the case of $W(151)$ with mass of ~ 50 eV since leptonic decays become impossible. The generation of $W^+(151)$ BE condensate is also energetically favorable due to the large Z^0 binding energy. $L(151)$ corresponds to the thickness of the cell membrane and to a minimal length of DNA double strand giving rise to an integer multiple of 2π twist with integer number (10) of DNA triplets. Note however that the large $\hbar$ length scale would be $L \sim nL(151 + 22 = 173) \simeq n \times 20$ μm. The decay of the BE condensate of dark $W(151)$ bosons (with large value of $\hbar$) to non-dark $W(151)$ bosons could allowing the control of $k = 151$ length scale by $k = 173$ length scale.

   In this case one would have $\Delta E \sim 5$ keV so that chiral selection would be highly stable. This option could be realized for linear bio-molecules. Hence the Bose-Einstein condensate of screening $k = 151$ W^+ bosons possessing net spin must be considered as a candidate for a mechanism inducing chiral selection of bio-polymers. The positive charge of the W^+ condensate could relate to the negative charge characterizing bio-polymers.

   If the order parameter of W^+ condensate around the molecule is spherically symmetric, the average interaction energy vanishes so that W bosons should possess also orbital angular momentum: the simplest option is that net angular momentum vanishes. The geometric breaking of spherical and reflection symmetries of the molecule would naturally induce the needed asymmetry of the order parameter.

7.8 Hydrogen bond revisited

Hydrogen bond is fundamental for the physics of water and believed to relate to its anomalous expansion at freezing point and anomalous contraction in heating above freezing point. Hydrogen bond plays also a key role in the living matter. Against this background it is perhaps somewhat surprising how poorly understood the physics of the hydrogen bond is.

The special role of hydrogen bond is consistent with the suggested role of dark Z^0 force. Hydrogen bond is believed to reflect ordinary Coulomb interaction between hydrogen bound to molecule and lost its electron partially to the molecule and electronegative atom (N, O, Cl,...) which has captured partially the electron of the atom with which its bonds, say C, and which therefore looks like having positive charge. Hydrogen bonds are in a key role in the binding of DNA strands, in the generation of geometric structure of proteins and RNA molecules, and also the molecular motors are constructed from their building blocks by hydrogen bonds. The reason why could be very simple: hydrogen bonds unlike valence and ionic bonds are relatively immune to the bio-control based on the variation of the classical Z^0 force by varying the Z^0 screening.

An interesting question is whether the hydrogen bonded state A+B of atoms A and B could be in a superposition of states with A and B in the ordinary state and a state in which A/B contains positively/negatively charged color bond changing the charge numbers A and B and effectively creating ionic bond.

If the hydrogen bond corresponds to a non-vacuum extremal in necessarily carries color gauge flux. Quantum classical correspondence together with the picture about nuclei as nuclear strings with nucleons connected by long color bonds forces to ask whether the nuclear strings of hydrogen bonded atoms fuse to form single nuclear string containing long straight section connecting the nuclei. Hydrogen bonded nuclei would become both colored and weakly charged in this kind of situation and would posses also a fractional electromagnetic charge not explainable in terms of fractional quantum Hall effect. In this kind of situation the first guess is that the exotic quark pairs associated with the color bond could play the role of valence electrons and characterize both the binding energy and parity breaking possibly associated with the bond.

8 Long ranged weak and color forces, phonons, and sensory qualia

Phase conjugate electromagnetic waves [42, 43] correspond in TGD framework negative energy topological light rays representing signals propagating to the geometric future [G3]. Phase conjugation is known to make sense even for sound waves [43]. Since phase conjugation means time reversal and negative energies in TGD framework, the only possible conclusion seems to be that classical sound waves and photons must correspond to their own space-time sheets. Depending on the time orientation of these space-time sheets, sound waves or their phase conjugates result in the interaction of these space-time sheets with matter.

If condensed matter is partially dark in the sense that nuclei tend to combine to form super-nuclei, the question arises whether dark weak force and dark nuclear strong force are involved with the sound waves besides em forces. Topological light rays ("massless extremals", briefly MEs) carrying classical gauge fields corresponding to an Abelian subgroup of the gauge group, be it color or electro-weak gauge group, and drifting quantum jump by quantum jump in the direction of sound wave define candidates for the space-time correlates of sound waves. Also the deformations of warped imbeddings of M^4 to $M^4 \times CP_2$ with maximal signal velocity reduced to sound velocity using M^4 as standard define candidate for the space-time sheets associated with sound waves.

In plasma phase classical electric field can cause plasma waves as longitudinal oscillations of charge density. Also the notion of Z^0 plasma wave makes sense if nuclei carry anomalous Z^0 charges due to charged color bonds. Entire dark hierarchy of these waves is possible. Even the counterparts of QCD plasma waves are possible.

8.1 Slowly varying periodic external force as the inducer of sound waves

The basic idea is that an external force, which is constant in the length scale of atomic nuclei or molecules sets them in a harmonic motion around equilibrium point. This slowly varying force is associated with the space-time sheet serving as the space-time correlate of phonon.

The basic fact about quantum physics of harmonic oscillator is that the resulting new ground state represents a *coherent* state having interpretation as a classical state of harmonic oscillator. If the external force depends periodically on time and spatial coordinates the intensity of the parameter characterizing coherent state varies in oscillatory manner and classical sound wave results as a consequence.

8.2 About space-time correlates of sound waves

Z^0 MEs ("massless extremals") represent transversal classical Z^0 fields propagating with light velocity. These transversal fields are candidates for the external force generating the coherent states giving rise to sound waves. There are however two problems.

1. How it is possible that sound velocity v is below light velocity?

2. How the Lorentz force orthogonal to the direction of propagation of classical fields inside ME can give rise to longitudinal sound waves.

One can imagine two solutions to these problems.

Option I: The first solution to both problems could be as follows. Let Z^0 ME represent a wave moving in z-direction with light velocity and let sound wave propagate in the direction of x-axis with sound velocity v_s. Assume that Z^0 electric field of linearly polarized ME is in x-direction, and thus defines a longitudinal force field inducing the coherent state. Also Z^0 magnetic field is present but for non-relativistic particles it is by a factor v/c weaker than Z^0 electric force and can be thus neglected.

Z^0 ME suffers in each quantum jump a shift consisting of a shift in z-direction and a shift in x-direction. The shift in the z-direction causes an effective reduction of the phase velocity of the field pattern inside ME. The shift in the x-direction means that the Z^0 electric field of ME moves is in x-direction and causes a longitudinal force. The velocity of the shifting motion in the x-direction must be sound velocity.

The classical force field is in a correct phase if Z^0 ME shifts in z-direction with such an average velocity that the phase $\omega t - kz$ along ME at point (t, x, y, z) changes to $\omega t - kz + \omega\Delta t - k_1\Delta x$ in the shift $x \rightarrow x + \Delta x$ of the position of ME resulting in quantum jump sequence corresponding to $t \rightarrow t + \Delta t$. This requires $\Delta z = (k_1/k)\Delta x$ giving $dz/dx = c/v_s$. Hence the rays $x = v_s t$ of constant phase for sound wave correspond to the rays of constant phase $z = ct$ along ME.

In the case of transversal sound oscillations possible in solid state Z^0 MEs shift in each quantum jump in z-direction in such a manner that effective phase velocity becomes sound velocity. Z^0 MEs generate oscillating transverse electric field inducing a coherent state of phonons. I have already earlier proposed that nerve pulse propagation corresponds to a propagation of Z^0 ME in an analogous manner [M2].

Option II: By quantum classical correspondence one might argue that sound propagation should have a direct space-time correlate. There exists an infinite variety of vacuum extremals with $D = 1$-dimensional CP_2 projection having a flat induced metric. These extremals correspond to warped imbeddings $m^0 = t, s^k = s^k(t)$ of M^4 with the induced metric $g_{tt} = 1 - R^2 s_{kl}\partial_t s^k \partial_t s^l$, $g_{ij} = -\delta_{ij}$. The maximal signal velocity using the canonical imbedding of M^4 as a reference is reduced to $c_\# = \sqrt{g_{tt}}$.

$D = 2$ vacuum deformations for this kind of space-time sheets exist but the great question mark are there non-vacuum deformations which correspond to solutions of field equations. Do they represent waves propagating with $c_\#$? This could be the case since the field equations for these deformations contain a term proportional to linearized d'Alembert equation in the background metric. Could phonon space-time sheets correspond to deformations of vacuum extremals of this kind analogous to MEs with $c_\#$ identifiable as sound velocity? Could phonons correspond to 3-D light-like surfaces representing wave fronts inside deformed vacuum extremals of this kind? Could the drifting of MEs have this kind of space-time sheets as a space-time correlate?

8.3 A more detailed description of classical sound waves in terms of Z^0 force

The proposed rough model is the simplest description in the case of condensed matter as long as the positions of particles vary slowly in the time scale of the oscillations associated with the sound wave.

A modified description applies when harmonic forces are between neighboring atoms. In this case the modification of standard wave equation would introduce a term representing external force to the wave equation. In one-dimensional case of one-dimensional periodic lattice with lattice constant a, elastic constant k for the elastic force between nearest neighbors, and atom mass m, one would have in the continuum approximation

$$\begin{aligned}(\partial_t^2 - v_s^2\nabla^2)A &= \frac{Q_Z E_Z}{ma} \ , \\ v_s^2 &= \frac{ka^2}{m} \ .\end{aligned} \tag{37}$$

Here a denotes lattice constant.

Temporally slowing varying Z^0 force to an harmonic external force yielding coherent states of the quantized system. Velocity resonance results when the external Z^0 field pattern has effective phase velocity equal to sound velocity $E_Z = f(u_+)$, $u_\pm = x \pm v_s t$. Writing the equations in the form

$$\partial_+\partial_- A = \frac{Q_Z f(u_+)}{ma} \ , \tag{38}$$

one finds that the general solution is of form

$$A = A_+(u_+) + A_-(u_-) + u_+\frac{Q_Z}{ma}\int du_- f(u_-) \ . \tag{39}$$

A_+ and A_- are arbitrary functions of their argument. In the absence of dissipative effects the amplitude increases without bound.

The quantization of the model is straightforward since a one-dimensional "massless" field coupled to an external source is in question with sound velocity taking the role of light velocity. The resulting asymptotic ground state is a product of coherent states for the frequencies present in the external force term. In quantum field theory this kind of state is interpreted as a maximally classical state and thus classical sound wave.

The intensity of the sound wave would be proportional to the modulus squared of the order parameter of the coherent state proportional to the Fourier transform of the classical Z^0 force. The standard classical model for sound waves would thus be only apparently correct. In TGD framework the screened dark Z^0 force gives a contribution also to the elastic forces between atoms and explains the strong repulsive potential below atomic distances implying incompressibility of condensed matter and needed in van der Waals equation of state.

Also in the hydrodynamics dark Z^0 force would take the role of an external force. Although the quantization of the Euler's equations is far from being a trivial task and perhaps not even sensible, the proposed picture is expected to be the same also in this case for small oscillations for which wave equation holds true. In TGD framework incompressible hydrodynamic flow is interpreted from the beginning in terms of dark Z^0 magnetic force [D1], and this should make possible a first principle quantization of sound waves in the case of liquid and gas phases.

1. The hydrodynamic flow occurs along the flux tubes of Z^0 magnetic field and it is quite possible that Z^0 superconductivity equivalent with super-fluidity along flux tube occurs in sufficiently short length scales. The presence of Z^0 magnetic flux tubes parallel to the flow lines is what makes possible to apply hydrodynamic description. The incompressibility inside Z^0 magnetic flux tubes is due to the fact that Z^0 magnetic field has a vanishing divergence. Alfwen waves, identifiable as transverse oscillations of magnetic flux tubes and propagating with light velocity along the flow lines should have Z^0 counterparts and might have detectable effects on the hydrodynamic flow.

2. The Beltrami condition $\nabla \times v = \alpha v$ guarantees that a coordinate varying along flow lines is globally defined and means that super-conducting order parameter defined along the flow

lines can be continued to a function defined everywhere so that there is Z^0 superconductivity also in the global sense. The complex patterns of flow reduce to the generalized Beltrami property of the topologically quantized flow. Also in the case of gas phase one expects incompressibility inside the flux tubes at least.

8.4 Does the physics of sound provide an operational definition of the dark Z^0 force?

The somewhat surprising conclusion supported by the existence of phase conjugate sound waves is that coherent sound waves could be a direct manifestation of the dark Z^0 force directly determining the amplitude of the sound wave understood as a coherent state. Therefore the problem of defining the notion of dark Z^0 force operationally would become trivial.

The hypothesis would predict that sound intensity for a given strength of the dark Z^0 field proportional to amplitude squared is proportional to $(N/k)^2$, where N is the anomalous color charge of the oscillating nucleus, and k elastic constant for the harmonic oscillations around the equilibrium position of (say) atom.

8.5 Weak plasma waves and the physics of living matter

In plasma phase electromagnetic MEs, and even more so scalar wave pulses, can generate plasma waves accompanied by longitudinal electric fields. In the case of scalar wave pulses the mechanism is simple: the longitudinal electric field of the scalar wave pulse kicks electrons so that a gradient of electron density results and oscillation starts at plasma frequency $\omega_p = e\sqrt{n/m_e}$ in the case of electron. The frequencies of transversal plasma waves are above the plasma frequency.

The notion of weak plasma frequency makes sense if condensed matter can be regarded as Z^0 plasma below the weak length scale L_w with nuclei carrying anomalous weak isospin $I_{3,L}$. Let $I_{3,L}$ be equal to N using neutron's isospin $I_{3,L} = 1/2$ as a unit so that single charged color bond corresponds to $N = \pm 2$.

For a hydrodynamic flow of water of density $\rho = 1$ kg/dm^3 giving $18n(H_2O) \simeq 10^{30}/m^3$ and $m(H_2O) = 18m_p$, W and Z^0 plasma frequencies are given by

$$\begin{aligned} \omega_p(W) &= g_W N\sqrt{n/m} \ , \\ \omega_p(Z^0) &= g_Z N\sqrt{\tfrac{1}{2} - sin^2(\theta_W)}\sqrt{n/m} = \sqrt{\frac{\frac{1}{2}-sin^2(\theta_W)}{sin^2(\theta_W)}} \times \omega_p(W) \ , \\ g_W^2 &= e^2 tan(\theta_W) \ , \quad g_Z^2 = \frac{e^2}{sin(\theta_W)cos(\theta_W)} \ , \quad sin^2(\theta_w) \simeq .23 \ . \end{aligned} \tag{40}$$

For $N = 2$ corresponding to single color bond Z^0 plasma frequency corresponds to an energy $E \simeq .062$ eV. Note that $\omega_p(W) = 1.08\omega_p(Z^0)$ is very near to $\omega_p(Z^0)$. The two plasma frequencies are identical for $p = 1/4$.

$\omega_p(W)$ is very nearly the frequency associated with the resting potential 0.065 eV of the cell membrane [M2]. Although this result could be a sheer co-incidence, it supports the idea that Z^0 plasma vacuum-screened in atomic length scale has a fundamental role in living matter. Of course, entire hierarchy of weak plasmas are possible and more or less forced by the fact that vacuum weak fields appear in all length scales. Weak scalar wave pulses would be an ideal tool for generating plasma oscillations whereas weak MEs would generate sound and transversal plasma waves.

8.6 Sensory qualia and dark forces

The TGD based model of sensory qualia relies on universality hypothesis stating that the increments of various quantum numbers in quantum jump define qualia at fundamental level in all p-adic length scales. The hierarchy of dark matters would allows to realize similar qualia in all length and time scales.

Quantum classical correspondence suggest that qualia identified as the increments of quantum numbers should have space-time correlates and charged components of weak and color gauge fields are natural candidates in this respect. If this interpretation is correct, sensations of qualia would be assignable to those space-time regions for which space-time sheet has $D > 2$-dimensional CP_2 projection. MEs would not thus serve as space-time correlates for qualia but only as communication and control tools.

$D = 3$ extremals allow interpretation them as analogs of spin glass phase possible in the vicinity of magnetization-demagnetization temperature whereas $D = 2$ phase would be analogous to ferromagnetic phase and $D = 4$ phase to de-magnetized phase [D1]. Spin glass property suggests the identification of $D = 3$ extremals as fundamental building bricks of living systems. $D = 3$ extremals have also extremely rich hidden order related to the topology of the field lines of the induced magnetic field lines. Therefore the interpretation of $D = 3$ extremals as space-time correlates of qualia is natural.

A couple of examples are in order.

1. Hearing could correspond to the increment of weak isospin or em charge (or both of them in fixed proportion) and to $D \geq 3$ weak space-time sheets. Classical W fields would serve as a space-time correlate for the basic quale associated with hearing.

2. The increments of color quantum numbers would correspond to the visual colors. The 3+3 charged components of classical gluon field would correspond to basic color-conjugate color pairs. The reduction to $U(2)$ subgroup of color group (for instance, CP_2 projection in $r = constant$ 3-sphere of CP_2) would correspond to the restriction of color vision to black-white vision. Non-vacuum extremals having $D > 2$ (also those having $D = 2$) carrying classical em fields are always accompanied by classical color fields so that the identification is not in conflict with the existing wisdom. Space-time sheets serving as correlates for color qualia would correspond to p-adic length scales associated with multiply dark gluons.

9 Mechanisms of Z^0 screening

9.1 General view about dark hierarchy

Classical color gauge fields are always present for non-vacuum extremals and non-Abelian classical weak fields always when the dimension D of the CP_2 projection of the space-time sheet satisfies $D > 2$. Quantum classical correspondence forces the conclusion that there must be a p-adic hierarchy of dark matters creating these fields in all length scales. At the level of quantum TGD the p-adic hierarchy of dark matters relates closely with the hierarchy of space-time sheets, hierarchy of infinite primes, and hierarchy of Jones inclusions for hyper-finite type II_1 factors. In TGD inspired theory of consciousness the hierarchy corresponds to the self hierarchy and hierarchy of moments of consciousness with increasing averages duration.

There already exists some guidelines about the physical realization of this hierarchy.

1. Already the p-adic mass calculations of hadron masses led to the conclusion that quarks can appear as several p-adically scaled up variants with masses of variants differing by a multiple of half-octave. There is also experimental support for the view that ordinary neutrinos can appear as several p-adically scaled up variants [24]. This forces to ask whether also electrons could appear as scaled up of scaled down variants even in the ordinary condensed matter, and whether the notion of effective mass of electron varying in wide limits could be replaced by p-adically scaled up mass. A testable prediction is atomic spectra scaled by a power of $\sqrt{2}$.

2. In the TGD based model for atomic nuclei as color bonded nucleons with the quarks/antiquarks at the ends of bonds are identified as p-adically scaled down quarks with electromagnetic space-time sheet having $k = 127$ rather than $k = 113$. Quite generally, exotic quarks and perhaps also leptons (possibly also their color excitations) with p-adically scaled down masses would be associated with the ends of join along boundaries bonds serving as correlates for the bound state formation.

3. The decay width of ordinary weak bosons force the conclusion that the weak space-time sheets associated with exotic quarks have $k \neq 89$ $k = 113$ is a good guess in this respect and would in large $\hbar$ phase correspond to a length scale of order atomic size. The model for tetra-neutron identifies tetra-neutron as alpha particle with two charge color bonds. There is no reason to assume that charged bonds could not appear also in heavier nuclei.

   Their presence would mean also that nucleus has anomalous em and weak charges. One can even consider the possibility that the nuclear strings of neighboring atoms fuse to single nuclear string with long straight portion so that nuclei become colored and possess fractional em charges. Also linking of the nuclear strings might occur.

   If this general picture forced by quantum classical correspondence is taken seriously, one begins to wonder whether even chemical bonds could involve light dark elementary fermions. These dark particles could couple to scaled down copies of both weak bosons and colored gluons.

   Chiral selection in living matter could be due to the axial part of weak interactions between exotic quarks of different nuclei. Even the low compressibility of liquid phase could be due to the Z^0 repulsion between nuclei having anomalous weak charges in condensed phase: note that no isotopic dependence is predicted as in the earlier proposal based on the assumption that ordinary quarks are Z^0 charged.

4. Besides color and electro-weak numbers dark particles can carry complex conformal weights expressible in terms of zeros of Riemann Zeta. If the conformal weight is conserved in particle reactions and given particle can correspond to only single complex conformal weight, it must be expressible in terms of conserved quantum numbers so that neutral particles have real conformal weights. In the transition to the next level of darkness the particles of previous level could receive complex conformal weights and color and weak quantum numbers.

5. Dark $\leftrightarrow$ visible phase transitions are describable as ordinary vertices in which also a scaling of $\hbar$ occurs and scales the size of the space-time sheet representing the particle.

9.2 Vacuum screening and screening by particles

Suppose that phase transitions generating charged color bonds and making molecules of condensed matter Z^0 charged with the same value of Z^0 charge are possible. This transition need not generate em charge since ordinary nuclear charge can be reduced in the transition. Weak charge is however generated. This kind of transition could proceed spontaneously as a two-nucleon process if the nuclei are close enough.

This raises the question about the basic mechanisms of screening of weak charges, in particular Z^0 charge. There are two basic mechanism of screening. Vacuum screening occurs automatically above weak length scale L_w and is responsible for the massivation of weak bosons. The screening by Z^0 charges of particles occurs in length scales $L \leq L_w$ in a dense weak(ly charged) plasma containing a large number of charged particles in the volume defined by L_w.

9.2.1 Vacuum screening

Vacuum screening occurs automatically and is based on the generation of vacuum charges which reduces the value of weak charge of particle at the weak space-time sheet associated with particle so that the flux feeded to the next sheet is reduced. This mechanism implies massivation of gauge bosons which at each space-time sheet behave classically like massless fields. It is basically the loss of coherence and correlations due to the finiteness of particle space-time sheet which implies the massivation and screening. The screening by vacuum charges makes sense only above the length scale L_w defined by the mass scale of weak bosons.

9.2.2 Screening by weakly charged dark particles

The screening by dark particles carrying weak charges is appropriate in weak plasma. In situation when the density of Z^0 charge is so high that L_w sized region contains large number of Z^0 charges, screening must be due to dark particles, such as dark electrons and neutrinos.

1. If ordinary atomic nuclei can make a transition to a phase in which $k = 113$ defines the weak length scale followed by a transition to dark phase with $\hbar_s = n\hbar/v_0$. For $n = 3$, the length scale L_w above which vacuum screening occurs is about nx Angstrom, where x varies in the range $[1, 2]$ and $n = 1, 2, 3, ...$ and screening by dark particles is not necessary in the densities typical to condensed matter. For $n = 3$ the L_w is in the range 3-6 A. The fact that the screening length is of the order of atomic size and length of a typical chemical bond means that dark weak force could play an important role in bio-catalysis as already discussed.

   The situation is quite different from that for Z^0 charge localized in nuclear volume. A complete screening by particles is achieved by constant density of Z^0 charge for the screening particles equal to the average Z^0 charge density of nuclei since the charge density to be screened is constant below L_w. By varying the density of screening particles the degree of Z^0 screening can be varied.

2. The hypothesis that weak bosons with complex conformal weights correspond to Gaussian Mersennes, such as the biologically highly interesting length scales $k = 151, 157, 163, 167$ varying in the biologically most interesting length scale range 10 nm-2.5 μm is worth of studying. This kind of dark particles could have ordinary value of $\hbar$ but would possess large weak size L_w. In condensed matter weak plasma phase would appear below the length scale $L(k)$ and the weak nuclear charges would be screened by dark electrons.

   Since the Z^0 charge density is constant below $L(k)$ screening by constant charge density of dark neutrinos is possible. Experimentally one cannot exclude the possibility that scaled up variants of ordinary neutrinos and their dark counterparts could appear at p-adic length scales $k = 151, ..., 167$. For instance, the model of nerve pulse relies crucially on the assumption that $k = 151$ cell membrane space-time sheet carries neutrinos [M2].

In the sequel a classical model of Z^0 screening by dark neutrinos generalizing the Debye model of ionic screening and a genuinely quantum model of screening based on the Bose-Einstein condensate of dark neutrino Cooper pairs are discussed. The Bose-Einstein condensate of sneutrinos predicted by space-time super-symmetry would be ideal for screening purposes. Super-conformal symmetries are basic symmetries of quantum TGD at the level of the "world of classical worlds" but it seems that sparticles are not predicted by quantum TGD if its recent interpretation is correct.

9.2.3 Different variants of Z^0 screening by particles

The model for the Z^0 screening allows to consider at least the following options.

1. Screening by a Bose-Einstein condensate

Some particles which are bosons would Bose-Einstein condense to the ground state. One can consider several options.

1. Sneutrinos, which are predicted by theories allowing space-time super-symmetry, would be nice option but there are reasons to believe that TGD does not predict them: super-symmetry would be realized only at the level of configuration space of 3-surfaces.

2. Cooper pairs of dark neutrinos is second candidate. A phonon exchange mechanism based on classical Z^0 force could allow the formation of Cooper pairs making possible neutrino super conductivity. This mechanism is discussed in some detail in [J3].

   The questionable feature of the Cooper pair option is that the density of neutrinos is so high as compared to the Compton length defined by the rest mass of the neutrino. One can ask whether it makes to sense to regard multi-neutrino state as consisting of Cooper pairs in this kind of situation.

3. The Bose-Einstein condensate of W bosons giving rise to W super-conductivity would define the third option. The simplest option is that the very process generating the charged color bonds in nuclei occurs via emission of W bosons taking also care of screening.

   For $k = 113$ dark W bosons this option is energetically problematic since the rest mass of dark W bosons with $k = 113$ is about 25 MeV and rather high and these bosons are also highly unstable. Note however that complete screening is not needed since vacuum screening occurs automatically above L_w, and W Bose-Einstein condensate could control the degree of Z^0 screening.

   For $k = 151$ W mass is ~ 50 eV and these bosons could be stable (if the masses of exotic leptons are small enough). The negative Z^0 Coulombic interaction energy with exotic quark, given roughly by $\sim 2\alpha_Z Q_Z^2(\nu)/a$, a atomic radius, is of same order of magnitude as the rest mass. Therefore the generation of $k = 151$ W Bose-Einstein BE condensate would require rather small net energy and would lead to a gain of energy for $k = 157, 163, 167$.

2. Dark neutrinos screen the Z^0 charge

For this option dark neutrinos do not form Cooper pairs and thus fill the whole Fermi sphere. For a complete screening the Fermi energy is extremely relativistic, of the order $\pi\hbar_s/a$, a atomic radius so that this option is not energetically favored despite the fact that the ground state energy is negative due to the large Z^0 interaction energy having magnitude larger than neutrino mass.

For full screening the value of the Fermi energy for dark neutrinos at level $k = k_Z$ is determined essentially by the density of anomalous isospin per nucleon. This implies that neutrinos at the top of Fermi surface are relativistic: the Fermi energy for N units of weak isospin per nucleon is given by

$$\begin{aligned} E_F &\simeq N^{1/3}\hbar_s\frac{\pi}{a} \ , \\ a &\simeq 10^{-10}\ m \end{aligned} \tag{41}$$

and does not depend on condensate level. The order of magnitude is 10^4 eV for ordinary value of $\hbar$ but $n \times 20$ MeV for $\hbar_s = n\hbar/v_0$ and of the same order of magnitude as the rest mass of dark W boson. Hence this option is not energetically much better than W boson option. As noticed, complete screening is not needed so that neutrino screening could serve control purposes.

9.3 A quantum model for the screening of the dark nuclear Z^0 charge

In the sequel a quantum model for the screening of dark Z^0 charge is discussed. There are several options corresponding to a screening by neutrinos, by their Cooper pairs, or by light variants of W bosons. The screening by sneutrinos predicted if the theory allows space-time super-symmetry but this does not seem to be the case in TGD.

9.3.1 Some relevant observations about dark neutrinos

The experimental data about neutrino mass differences suggests that neutrinos correspond to the p-adic length scale $k = 169$ and possibly also some larger p-adic primes such as $k = 173$ [24]. $k = 169$ neutrinos would have Compton length of about $L(169)$, cell size.

Neutrinos with dark $k = 113$ weak space-time sheet need of course not correspond to the same p-adic length scale as ordinary neutrinos but one can make this assumption as a convenient working hypothesis in order to get some acquaintance with the numbers involved.

A constant Z^0 charge density of dark neutrino background can in principle cancel $k = 113$ dark Z^0 charge density which is constant in length scales $L < L_w(k_{eff} = 137)$ of order atomic size. The degree of screening is the proper parameter and cannot vary considerably in length scales smaller than $L(169)$ since this would require highly energetic neutrinos.

The Fermi sea of dark neutrinos screening completely the anomalous Z^0 charge of nuclei gives rise to Fermi momentum equal to $E_F = p_F = \hbar_s n^{1/3} \simeq N^{1/3}\hbar/L(137) \simeq N^{1/3}(\hbar_s/\hbar) \times 10^4$ eV but this requires energy. Here N is the number of Z^0 charges per nucleus.

9.3.2 The model of Z^0 screening based on harmonic oscillator potential does not work

The density of the nuclei is so high that there is large number of nuclei within the Bohr radius, which increases by a factor n/v_0 in large $\hbar$ phase. Also the fact that Z^0 charge density is constant within L_w favors a different treatment.

The first guess is that the presence of the anomalous nuclear Z^0 charge could be treated as a harmonic oscillator potential with origin at the center of the region containing the dark phase. One might hope that this treatment makes sense if the nuclei can be regarded as forming a fixed background stabilized by electromagnetic interactions and by screening. The objection is that translational invariance is lost. It is easy to see that the treatment fails also for other reasons.

The effective potential is given by

$$\begin{aligned} V_{eff} &= \frac{E}{m}V_Z - \frac{V_Z^2}{2m_\nu} \ , \\ V_Z &= \frac{kr^2}{2} \ , \\ k &= \frac{1}{3}Q_Z^2(\nu)\hbar_s\alpha_Z N\rho_n \ , \end{aligned} \tag{42}$$

where $\rho_n \equiv 1/a^3$ is the number density of nuclei. N is the Z^0 charge per nucleus due to the charged color bonds using $Q_Z(\nu)$ as a unit.

The presence of the relativistic correction in-stabilizes the system above some critical value of r. The maximum $V = E^2/2m_\nu$ of the effective potential at $V = E$ corresponds to

$$r = \sqrt{\frac{6Ea^3}{\hbar_s}} \times \sqrt{\frac{1}{\alpha_Z N Q_Z^2(\nu)}} \ . \tag{43}$$

For non-relativistic energies the order of magnitude for r is

$$r \sim \sqrt{v_0 m_\nu a}/\sqrt{N\alpha_Z Q_Z^2(\nu)}$$

and smaller than the atomic radius. Thus it would seem that the potential is in practice repulsive in the non-relativistic case. For negative energies the potential is repulsive everywhere. Even for relativistic energies of of order $\hbar_s/a$ at the Fermi surface one has $r \sim a/\sqrt{N\alpha_Z Q_Z^2(\nu)}$ and not much larger than atomic radius. Obviously the treatment of nuclei in the proposed manner does not work.

9.3.3 The model for Z^0 screening based on constant potential well

Since Z^0 charge density is constant within L_w, the safest manner to describe the system is as free dark neutrinos or neutrino Cooper pairs in a potential well characterized by the average Z^0 interaction energy of neutrino with nucleus, both idealized as balls of radius L_w carrying a constant Z^0 charge density.

By performing a time dependent gauge transformation

$$Z^0_\mu \rightarrow Z^0_\mu + \partial_\mu \Phi \ \ , \ \ \Phi = V_Z t \times \chi \ \ ,$$

where χ equals to unity inside the potential well and vanishes outside, free d'Alembert equation inside potential well results and solutions can be written as standing waves, which must vanish at the boundary of the well to minimize the singularity resulting from the fact that $A_\mu A^\mu$ term gives square of delta function at boundary. The energy identified from the time dependence of the phase factor of solution is $E_0 + V_Z = \sqrt{p^2+m^2} + V_Z$ as the non-relativistic treatment would suggest. Negative energy states obviously result if Z^0 Coulomb interaction energy $E \sim \alpha_Z Q_Z^2(\nu)N/a$ is larger than neutrino mass.

9.3.4 Is Bose-Einstein condensate generated spontaneously?

The formation of neutrino Cooper pairs would correspond to the pairing of neutrinos of opposite spin and would be analogous to the pairing of valence electrons and nucleon pairs inside nuclei. The Bose-Einstein condensation would result basically from the energy gap between the states at the top of Fermi sphere and bound states formed via the scattering possible at the top of Fermi sphere. If the Z^0 interaction energy of neutrinos is negative and has larger magnitude than the rest mass at the bottom of Fermi sphere, it is energetically favorable to generate Fermi sea up to a positive energy for which the neutrino system vanishes. Zero energy neutrino-antineutrino pairs for which neutrino has negative energy could be created spontaneously from vacuum and the condensate could thus be generated spontaneously.

$k = 151$ W bosons could form automatically Bose-Einstein condensate. The fact that Z^0 interaction energy has larger magnitude than W boson mass favors the spontaneous occurrence of the process. If W bosons are created by the phase transition generating charged color bonds in nuclei their charge is automatically screened.

It is illustrative to recall the basic aspects of the model for Bose-Einstein condensation in the case of ordinary ideal Boson gas.

1. In the absence of the classical Z^0 force the energy spectrum of non-relativistic neutrino Cooper pairs is that for a particle in box: $E_n = k\sum_i n_i^2 \times \pi^2/mL^2(169)$, where k is a numerical factor k characterizing the geometry. The natural unit of energy is $\pi^2\hbar^2/2mL^2(169) \simeq .05$ eV.

2. The critical temperature for Bose-Einstein condensation is in recent case obtained by applying the general formula applying in the case of free boson gas with fixed particle number N in volume V:

$$T_c = \frac{2\pi\hbar_s^2}{m}(\frac{n}{2.61})^{2/3} = 2\pi\hbar_s^2 \times (\frac{A-Z}{2.61})^{2/3} \times \frac{a^2}{m} \ . \tag{44}$$

T_c is of order .1 GeV so that Bose-Einstein condensation certainly occurs. The fraction of Bose-Einstein condensed particles is given by

$$\frac{N_{BE}}{N} = 1 - (\frac{T}{T_c})^{3/2} \ . \tag{45}$$

From these estimates it should be obvious that also in the recent case Bose Einstein condensation indeed can occur and that most of the bosons are in the negative energy state.

10 Appendix: Dark neutrino atoms

Dark neutrinos provide a possible screening mechanism for classical Z^0 force present in dark condensed matter with weak bosons in dark $k = 113$ phase. If one takes seriously recent experimental evidence [30] and the explanation of the anomalous atmospheric μ/e ratio [31] in terms of neutrino mixing one must conclude that ν_μ and ν_τ are condensed on $k = k_Z$ level and that muon and τ neutrino have suffered large mixing whereas the mixing of ν_e with remaining neutrinos is much small.

The discussion of [F3] led to the predictions for neutrino masses as a function of common condensation level. In the following table also the $k = 13^2 = 169$ level is included since it predicts exactly the best fit value for $\nu_\tau - \nu_\mu$ mass squared difference whereas $k = 167$ predicts it within 90 per cent confidence limits. $k = 169 = 13^2$ would be allowed if the physically interesting k:s are powers of primes instead of primes: this introduces only few new p-adic length scales below one meter.

k	$m(\nu_e)/eV$	$m(\nu_\mu)/eV$	$m(\nu_\tau/eV$
163	2.16	5.28	5.36
167	.54	1.32	1.34
$169 = 13^2$	.27	.66	.67

Table 2. The table gives the masses of neutrinos as predicted by p-adic mass calculations for three condensate levels.

Only $k = 167$ is allowed by the experimental constraints and p-adic length scale hypothesis in its most stringent form. It must be however emphasized that the elementary particle black hole analogy, discussed in the third part of the book, allows also $k = 169 = 13^2$ giving the best fit to the neutrino mass squared differences. Since the experimental results about electron neutrino-muon neutrino mass difference are preliminary one cannot however exclude the existence of heavy τ neutrino effecting screening of classical Z^0 force in atomic length scales. The upper bound $.3\ MeV$ of neutrino mass almost allows $k = 131$ τ neutrino with mass of $.4\ MeV$ and it is interesting to find whether $k = 131$ τ is physically acceptable alternative. It turns out that this is not the case.

10.1 Dark neutrino atoms in non-relativistic approximation

To get order of magnitude picture it is useful to look first the Bohr radii and ground state energies for dark neutrino atoms assuming that the non-relativistic approximation makes sense. The Bohr radius $a_\nu = \frac{1}{m_\nu \alpha_Z Q_z^2(\nu)(A-Z)}$ and ground state energy of the neutrino atom read in terms of the ordinary Bohr radius $a_0 \simeq 0.5 \cdot 10^{-10}\ m$ and hydrogen atom ground state energy $E_H \simeq 13.6\ eV$

$$\begin{aligned} a_\nu &= \frac{m_e}{m_\nu}\frac{\alpha_{em}}{\alpha_Z Q_Z^2(\nu)}\frac{a_0}{(A-Z)} \\ &\simeq \frac{m_e}{m_\nu} X \frac{a_0}{(A-Z)} \ , \\ E_\nu &= X^{-2}\frac{m_\nu}{m_e}(A-Z)^2 E_H \ , \\ X &= \frac{sin(\theta_W)cos(\theta_W)}{Q_Z^2(\nu)} \simeq 1.68 \ . \end{aligned} \tag{46}$$

For $\nu_\tau(131)$ (see the table below) Bohr radius is $a(\nu) = 1.95a_0 = 1.05L(137)$ and quite near to the typical size of lattice cell in condensed matter systems.

ν	m	a_ν	E_0/eV	T_I/K
$\nu_\tau(131)$	$0.45\ MeV$	$7.5E-10\ m$	4.3	$.5E+4$
$\nu_{\mu,\tau}(167)$	$1.32\ eV$	$12.8\ \mu m$	$1.32E-5$	.13
$\nu_e(167)$	$.45\ eV$	$49.8 \mu m$	$.40E-5$	.04

Table 3. Table gives Bohr radius, energy of ground state and ionization temperature for ground state of neutrino atom for different neutrino species. Data are also given for $k = 131$ τ neutrino.

For dark matter densities which are of order condensed matter densities neutrino atoms are not possible. One can however consider the possibility that a block of dark matter takes the role of "super nucleus" creating a neutrino "super-atom" with Bohr radius $\propto 1/N(A-Z)$ and binding energy $\propto N^2(A-Z)^2$, where N is the number of nuclei involved.

The observation of the spectral lines of $k = k_Z$ dark neutrino atoms would be a triumph of the theory. The transitions between different energy levels can take place via photon/phonon emission/absorption and the observation of the predicted hydrogen type emission and absorption lines or their phonon counterparts would be a direct verification of the theory.

1. A possible signature of neutrino atoms is weak absorption of light at energies of order $10^{-5}\ eV$. In dipole approximation the transition amplitudes are proportional to the sum of matrix elements for electronic and nuclear dipole moment operators so that matrix elements $(m|\bar{r}(nucleus)|n)$ and $(m|\bar{r}(electron)|n)$ are involved. The coordinate vector operators $\bar{r}(nucleus)$ and $\bar{r}(electron)$ must be expressed in terms of cm coordinates and they contain a small contribution proportional $\frac{m_\nu}{M(nucleus)}\bar{r}_\nu$ as is clear from $\bar{r}(nucleus) = \bar{r}_{cm} + \frac{m_\nu}{m(nucleus)+m_\nu}\bar{r}_{12}$ and corresponding expression for electronic coordinate vector. These terms proportional to $\bar{r}_\nu$ induce transitions between different neutrino energy levels. The transition rates are by a factor $\frac{m_\nu^2}{m^2(nucleus)} \sim 10^{-18}/A^2$ (!) smaller than their atomic physics counter

parts. Transition rates are also proportional to the square of the energy difference between the levels in question and this gives additional factor of order 10^{-10} for neutrino atoms so that reduction factor of order 10^{-38} results! The observation of $k = 167$ neutrino atoms requires temperature of order .1 K and very low densities (fraction of order 10^{-12} of ordinary condensed matter density) and one can conclude that the observation of $k = 167$ neutrino atoms is extremely difficult by photon emission or absorption.

2. One can also consider the possibility of observing dark neutrino atoms via phonon absorption or emission: the coupling of the neutrinos to phonons would result indirectly from the coupling of neutrinos to atomic nuclei via classical Z^0 force and from the coupling of nuclei to phonons. A rough estimate for the relevant wavelength of sound in temperature of order .1 K gives for the wavelength of the phonon associated with transitions $\lambda \sim 10^{-9}$ meters and frequency of order 10^{10} Hz.

10.2 A relativistic model for dark neutrino atom

The Z^0 gauge potential around nucleus is very strong and the classical estimate for the neutrino Coulombic energy has a magnitude much larger than the rest mass of neutrino. This suggests that neutrinos and their Cooper pairs could form negative energy states around nucleus.

For neutrino atoms with several neutrinos one must take into account the screening effect of neutrinos to the Z^0 Coulombic potential of the nucleon. The self consistent model is based on the relativistic counterpart of the Schrödinger equation for the order parameter describing bosons in the Z^0 Coulomb potential created by the nucleus and neutrino charge density.

10.2.1 Self consistent relativistic Schrödinger equation as a model for Z^0 screening

The Laplace equation for the self-consistent Z^0 Coulomb potential reads as

$$\nabla^2 V_Z = -g_Z^2 Q_Z^2(\nu)(A-Z)\delta(\bar{r}) + g_Z^2 Q_Z^2 \overline{\Psi}\partial_t\Psi \ . \tag{47}$$

In the lowest order approximation the solution of this equation is Coulomb interaction energy of neutrino with nucleus

$$\begin{aligned} V_Z^0 &= -\frac{k_Z}{r} \ , \\ k_Z &= \alpha_Z Q_Z^2(\nu)(A-Z) \ . \end{aligned} \tag{48}$$

The d'Alembert equation for the order parameter Ψ characterizing a Bose-Einstein condensate of Cooper pairs of mass m reads as

$$\left[(-i\partial_t - V_Z)^2 + \nabla^2\right]\Psi = m^2\Psi \ . \tag{49}$$

Specializing to stationary solutions $\Psi \propto exp(iEt)$ corresponding to energy eigenstate and assuming spherically symmetric potential, one has $\Psi = R(r)Y_m^l(\theta,\phi)$.

If $|\Psi|^2$ is spherically symmetric as one can assume under rather general conditions, the model reduces to ordinary differential equations and one can solve it numerically by iterating. By writing V_Z in the form $V_Z = f_Z/r$ one can readily integrate V_Z from

$$V_Z = -\frac{k_Z}{r} + \frac{g_Z^2 Q_Z^2 E}{r}\int_0^r dr_2 \int_0^{r_2} dr_1 r_1 R^2(r_1) \ . \tag{50}$$

10.2.2 Bound states

It is possible to understand the general properties of this equation by transforming in to a form which allows to use the rather precise analogy with Schrödinger equation for hydrogen atom. There are two cases to be considered: bound states and negative energy resonances.

For the bound states the appropriate representation of the equation is

$$\left[-\frac{1}{2m}(\partial_r^2+\frac{2}{r}\partial_r+\frac{l(l+1)}{r^2})+\frac{E}{m}V_Z-\frac{V_Z^2}{2m}\right]R \;=\; \frac{(E^2-m^2)}{2m}\times R \ . \tag{51}$$

When the screening is not taken into account, the equation has a close resemblance with the Schrödinger equation for the hydrogen atom. The correspondences are following:

$$k_{eff}=\frac{E}{2m}k \ , \quad E_{eff}=\frac{E^2-m^2}{2m} \ , \quad l_{eff}(l_{eff}+1)=l(l+1)-k_Z^2 \ . \tag{52}$$

In the analog of Schrödinger equation Coulombic potential energy is replaced by an effective potential energy

$$V_{eff} \;=\; \frac{E}{m}V_Z-\frac{V_Z^2}{2m} \ . \tag{53}$$

V_{eff} is negative for large values of V_Z, vanishes for $V=-2E$, has a maximum $V_{eff}(max)=E^2/2m$ for $V=E$ and vanishes asymptotically. Therefore V_{eff} has an attractive infinitely deep well surrounded by a potential wall of height $E^2/2m$ so that tunnelling in principle becomes possible. Since V^2 term only modifies the effective value of the angular momentum, it is possible to solve the Schrödinger equation explicitly. Bound states correspond to $E<m$. Bound states are non-relativistic with a very long range m/k_Z^2 of about 10^{-4} meters and are not interesting as far as local screening of Z^0 charge is considered.

10.2.3 Negative energy resonances

Relativistic negative energy resonance like solutions can be localized below the atomic radius and only these are appropriate for local screening of the Z^0 charge. For these solutions it is natural to replace the mass of the Cooper pair with its energy $|E|$. With a little re-arranging the following equation analogous to Schrödinger equation for hydrogen atom

$$\left[-\frac{1}{2|E|}(\partial_r^2+\frac{2}{r}\partial_r+\frac{l(l+1)}{r^2})-\frac{E}{|E|}V_Z-\frac{V_Z^2}{2|E|}\right]R \;=\; \frac{(E^2-m^2)}{2|E|}R \ . \tag{54}$$

In the lowest order approximation one can use the unscreened Z^0 Coulombic potential allowing very close analogy with the hydrogen atom. The analogy with the hydrogen atom is revealed by the replacements

$$m_{eff}=|E| \ , \quad k_{eff}=\frac{k_Z}{2} \ , \quad E_{eff}=\frac{E^2-m^2}{2|E|} \ , \quad l_{eff}(l_{eff}+1)=l(l+1)-k_Z^2 \ . \tag{55}$$

Note that l_{eff} can be also negative and that for negative energies the Coulombic potential term represents an attractive potential although one has $E_{eff}>0$. Thus the proper interpretation of the negative energy states are as kind of resonance states.

10.2.4 An upper bound on the neutron number of nucleus

The general solution for l_{eff} allows to branches

$$l_{eff} = -\frac{1}{2} \pm \frac{1}{2}\sqrt{1+4l(l+1)-4k_Z^2} \ . \quad (56)$$

The second branch allows $l_{eff} < 0$ even when the right hand side of the equation above is positive.

The condition

$$l(l+1) > k_Z^2 - \tfrac{1}{4} \quad (57)$$

guaranteing the reality of l_{eff} must be satisfied. This condition is automatically satisfied for $l = 0$ for nuclei satisfying $k_Z < 1/2$: this gives

$$A - Z \leq \frac{1}{2\alpha_Z Q_Z^2(\nu)} \ . \quad (58)$$

For biologically important nuclei the condition is satisfied since the lower bound is very roughly $A - Z = 60$.

For $l > 0$ solutions the neutrino perturbation of the Coulombic potential is not spherically symmetric. Hence only $l = 0$ solution allows a simple numerical treatment based on ordinary differential equations.

10.2.5 The behavior of the negative energy solutions near origin

One can apply standard methods used for solving the Schrödinger equation for hydrogen atom also in the recent case.

1. One can write the normalized order parameter R in the form

$$R(r) = N \times r^{l_{eff}+1} \times exp(-i\frac{r}{|r_0|}) \times w(r) \ . \quad (59)$$

The counterpart of Bohr radius is given by

$$|r_0| = \frac{1}{\sqrt{2E_{eff}m_{eff}}} = \frac{1}{\sqrt{E^2-m^2}} \ . \quad (60)$$

For relativistic negative energy solutions the counterpart of Bohr radius is imaginary so that the exponential represents spherical wave.

2. Negative energy solutions are slightly singular at origin as are also the solutions of the relativistic Dirac equation. The requirement that the solution is square integrable at origin gives

$$l_{eff} > -\frac{5}{2} \ , \quad (61)$$

The behavior $R^2r^2 \propto r^{2\delta}/r$ for $|\Psi|^2$ near origin is therefore the most singular option.

A more stringent condition results if one requires that the interaction energy between neutrinos and nucleus is finite. In the lowest order the interaction energy density behaves as $r^{2l_{eff}+1}$ so that the constraint reads as

$$l_{eff} \quad > \quad -2 \ . \tag{62}$$

If one requires that neutrino-neutrino Coulombic interaction energy is finite one has

$$l_{eff} \quad > \quad -\frac{5}{4} \ . \tag{63}$$

At large distances $1/r^{1-2\delta}$ even the most singular behavior of $|\Psi|^2$ does not guarantee square integrability but in present case one is interested in non-localized solutions analogous to those characterizing conduction electrons and square integrability is not needed. From the condition

$$l_{eff}(l_{eff}+1) \quad = \quad l(l+1) - k_Z^2 = l(l+1) - \alpha_Z(A-Z)Q_Z^2(\nu) \tag{64}$$

it is clear l_{eff} can be negative only for $l = 0$ solution for nuclei for which the condition $A - Z < \alpha_Z Q_Z^2$ is satisfied.

10.2.6 The condition determining the energy eigen values

In the case of bound states the function $w(\rho)$ reduces to a polynomial. Also for the negative energies one can consider analogous solution ansatz as a representation of a negative energy resonance state.

1. The condition for the reduction to a polynomial can be deduced using standard power series expansion and reads as

$$2(k + l_{eff} + 1) \quad = \quad -\frac{k_{eff}}{|E_{eff}r_0|} = -k_Z \times \left[\frac{|E|m}{E^2 - m^2}\right]^{1/2} \ . \tag{65}$$

2. One can write l_{eff} in the form $l_{eff} = -l_{eff}(min) + \Delta l$, where the value of $l_{eff}(min) = -7/2, 2$, or $-5/4$ depending on the regularity conditions at the origin so that the condition Eq. 65 gives

$$k \quad < \quad -l_{eff}(min) - 1 - \Delta l \geq \frac{1}{4} - \Delta l \ . \tag{66}$$

w is at most a first order polynomial in r. The most stringent condition guaranteing the finiteness of Z^0 interaction energy allows only the solution for which $w(\rho)$ is constant.

3. The condition of Eq. 65 guaranteing the reduction of the series of w to a polynomial reduces to the form

$$1 - 2\delta \quad = \quad k_Z \times \left[\frac{|E|m}{E^2 - m^2}\right]^{1/2} \ . \tag{67}$$

The solutions are

$$\frac{|E|}{m} = \left[b \pm \sqrt{b^2-1}\right]^{1/2} ,$$
$$b = 1 + \frac{k_Z^2}{2(1+2\delta^2)^2} . \qquad (68)$$

Solutions are relativistic negative energy solutions but the energy is of the same order of magnitude as the rest energy so that the total energy of the Bose-Einstein condensate is relatively small. Note that the solution is scaling covariant in the sense that in the p-adic scaling $m \rightarrow 2^k m$ also energy scales in the same manner.

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